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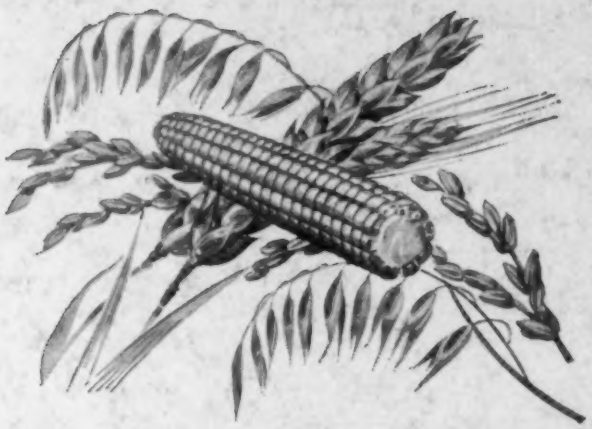

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The Journal of Pediatrics

VOL. 24 JANUARY, 1944 NO. 1

Original Communications

SUBDURAL HEMATOMA IN INFANCY

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BOSTON, MASS.

INTRODUCTION

THE clinical picture of an adult patient complaining of increasing headache, drowsiness, blurred vision, mental confusion, occasional vomiting, or any combination of these symptoms, and giving a history of a closed head injury anywhere from a few days to several months previously has become widely recognized as characteristic of chronic subdural hematoma. Clinics which care for any quantity of traumatic cases see these patients frequently and diagnose and treat them with considerable facility. A voluminous literature on the general subject of subdural hematoma has resulted. Analysis of series of many carefully studied and uniformly treated cases in patients, such as those of Munro,[1] and Dyke,[2] and Horrax and Poppen,[3] are available and familiar not only to neurosurgeons, but to general surgeons and general practitioners as well.

There has been a great increase in the number of head injuries among the civilian population in districts that have felt the impact of the bombing of modern warfare. Also, the percentage of similar injuries among military personnel both in training and combat has been significantly greater. As a result, many physicians with no previous experience with head trauma have, of necessity, become acquainted with this type of injury in the adult.

Very little has been recorded, however, about the occurrence and management of subdural hematoma in infancy. It is a common condition during the first two years of life and the source of a high morbidity if neglected. Mental retardation is an almost uniform result of the cerebral deficiency incident to hematoma in infants in this age group. The existence of a much larger number of these damaged children than is generally realized, many of whom might be spared with proper treatment, warrants this presentation of our experience with the lesion.

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In 1930 Sherwood[4] reported nine cases of subdural hematoma in infancy observed over a period of about four years. In 1932 Peet and Kahn[5] presented nine cases, and in 1934 Naffziger and Brown[6] reported five cases. In 1939 Ingraham and Heyl[7] reviewed the cases in children who had been cared for at The Children's Hospital up to that time and reported in some detail the cases of eleven patients who had been treated more or less radically according to a standard program during the previous year. Since that time there have been reports of eleven cases by Dowman and Kahn in 1942[8] and of single cases by Coblentz in 1940[9] and Rogatz in 1942.[10] In addition, articles in numerous textbooks and Systems of Pediatrics describe the lesion and refer to occasional cases.

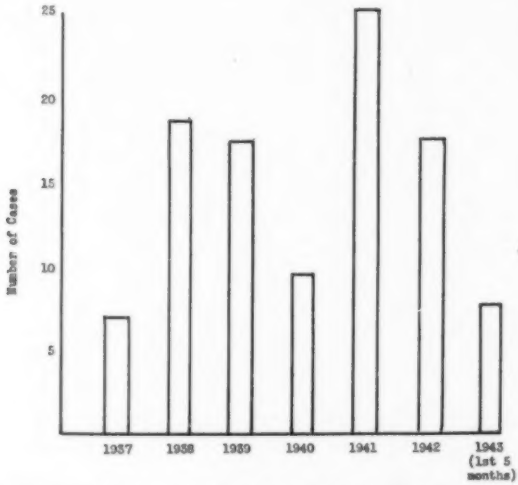


Fig. 1.—Incidence of new cases of subdural hematoma during the last six years at The Children's Hospital. An average of about seventeen cases a year has been seen.

At The Children's Hospital, the series has now been extended to ninety-eight cases, all the children of whom have been treated under supervision of the neurosurgical service according to a uniform plan. This includes only patients seen since 1937, when the present program was first adopted. Enough patients have now been seen to justify some appraisal of the results of this type of therapy.

Previous to 1937 only two or three patients with subdural hematoma per year were seen. We feel certain that the apparent rise in the incidence of the disease in our hospital population during the last six years is not a real one. Increased interest has led to a more diligent search for these patients, and the results have been gratifying. As shown in Fig. 1, the number of children seen per year during the last five and one-half years has been essentially the same, indicating that there is

probably a fairly constant incidence of the lesion. There is no reason to think there is geographic prevalence of this disease. We believe, therefore, as stated previously,[7] that the frequency with which subdural hematoma is found in infancy is largely proportional to the intensity with which it is sought.

The ultimate treatment of subdural hematoma by such a regimen as will be outlined in this paper is ideally carried out under the direction of an experienced neurosurgeon in a clinic equipped with the special armamentarium of modern neurosurgery and with the use of special techniques for handling surgical problems in infants. However, the detection of these lesions in the general population and the early and accurate diagnosis, or at least suspicion of the diagnosis, is definitely a problem of the pediatrician and the general practitioner. Emphasis of this realization is a primary purpose of this report.

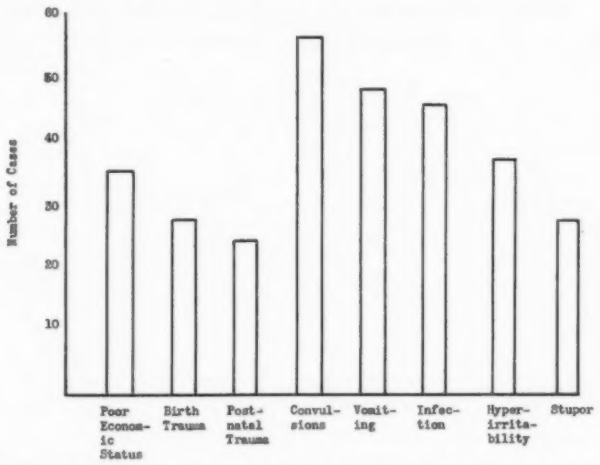


Fig. 2.—Common symptoms in the history as elicited from parents or other informants.

ETIOLOGY

The most important etiologic factor in subdural hematoma in infancy, as in all other age groups, is trauma to the head. As seen in Fig. 2, in over one-half of our patients there was a definite history of trauma to which the lesion could reasonably be traced. Twenty-eight patients were known to have experienced severe trauma at birth. We feel certain that this number should be higher, as it is so frequently impossible to obtain an accurate history of the circumstances of delivery. Also, at the time of admission to the hospital many patients showed other evidence of birth trauma.

Postnatal trauma must also be a much more frequent etiologic factor than is apparent from the casually elicited history. It is well known

that the head injury which gives rise to subdural hematoma need not be a severe one. The fact that only eleven of these ninety-eight patients had skull fractures visible by x-ray is evidence of this fact. A moving object which strikes the head gives rise to localized injury to the scalp and skull but does not greatly derange the relative position of intracranial structures. However, when the moving head is suddenly stopped by striking an immovable object, there is apt to be sudden and perhaps quite marked rearrangement of the brain and meninges in relation to one another and to the skull. It is the latter type of trauma, occurring especially in falls on the frontal and occipital regions, which apparently results in tearing of the tributary veins leading from the superior aspect of the cerebral cortex to the longitudinal sinus. The high percentage of bilateral lesions suggests also that it is a general shift of intracranial contents rather than any localized injury which causes this type of bleeding. During the first two years of life this type of fall is common and is very apt to go unnoticed or be quickly forgotten by the parent or nursemaid.

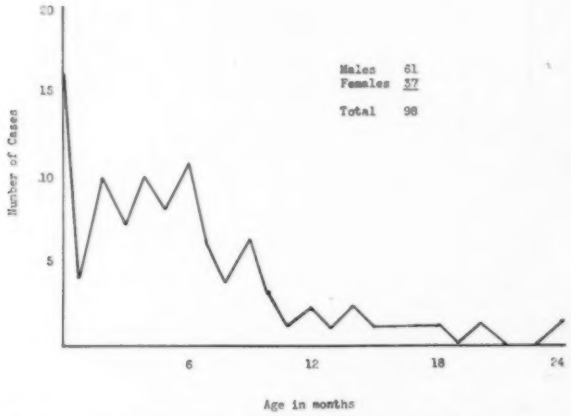


Fig. 3.—Distribution of cases according to sex and age in months at the time of hospital admission.

The trauma experienced during difficult labor and delivery is probably of the same type. Moulding of the head with tension on the intracranial soft parts could, theoretically at least, easily rupture the delicate bridging veins. As Fig. 3 shows, the greatest incidence is during the first six months of life. How many of these cases represent hematomas dating from birth injury is not clear, but it seems likely that a high percentage of them do when the age of the hematoma pathologically and a careful scrutiny of the baby's history are taken into consideration.

The significance of systemic disease in the etiology of subdural hematoma in infants in this age group is not at all certain. Ingalls[11] studied

the relation of this lesion to vitamin C deficiency in infants and concluded that in most cases an underlying bleeding diathesis on the basis of scurvy was present and that free subdural bleeding was then more readily produced by a definite or perhaps insignificant head trauma. Certainly scurvy, vitamin K deficiency in the newborn infant, or any other disease giving rise to an increased bleeding tendency should increase the possibility of subdural clot formation under suitable conditions. Twenty of our patients showed some clinical evidence of vitamin C deficiency, but it could by no means be considered a uniform or even very common finding.

Almost one-half of the patients (Fig. 2) showed evidence of infection somewhere else in the body at the time of hospitalization. This was usually of the respiratory tract, but gastroenteritis and urinary infections were also seen. This probably represents only a manifestation of the poor general condition and frequent malnutrition of these patients. More than one-third of our patients came from homes where the economic status was definitely poor, and in many more it could only be considered barely fair.

It seems justifiable to us to conclude that some form of trauma is practically a constant etiologic factor. In malnourished and diseased infants it may take less injury to produce this lesion, and in poor economic surroundings the exposure rate to adequate trauma is undoubtedly higher, but the common denominator probably remains the same. We should like to emphasize again, however, the inadequacy of the history in many of these infants. Because of this, the absence of a history of trauma should never influence the diagnosis against subdural hematoma.

SYMPTOMS

There is no clinical picture which is absolutely characteristic of this lesion in infancy, but there are common groups of symptoms and signs which suggest it and which should be familiar to all pediatricians. Alertness to the frequency with which intracranial disease in early childhood is manifested by generalized symptoms such as failure to gain in weight, fever, vomiting, and irritability, as well as by the signs more customarily referred to the central nervous system, such as coma, headache, convulsions, and paralysis, is extremely important.

In Fig. 2 is shown the frequency with which various symptoms were noted among our patients at the time of hospital admission. It is readily apparent that the commonest ones, convulsions, vomiting, and irritability, are also characteristic of many other types of diseases in the same age group. The coexistence of infection in such a high percentage of these babies is also a frequently misleading factor.

The commonest symptom noted was convulsions. These occurred in over one-half (fifty-five) of our patients. The convulsions may be localized to one side, one extremity, or even limited to twitching of one side of the face. More often they are generalized and accompanied by loss

of consciousness. They have been seen varying in severity from simple staring attacks to severe generalized seizures accompanied by high fever and respiratory embarrassment and followed by prolonged coma. In other words, there is nothing characteristic about the convulsions of subdural hematoma to distinguish them from seizures due to other causes. The coexistence of low calcium tetany or of high fever due to infection may obscure the real etiology of the convulsions.

Vomiting was an admitting symptom in almost one-half (forty-seven patients) of our series. This may or may not be of the forceful variety traditionally described as characteristic of increased intracranial pressure. Thirty-six patients were described as having shown hyperirritability, excessive crying, or restlessness. Twenty-seven were either stuporous at the time of admission or gave a history of periods when they could not be aroused by ordinary stimuli.

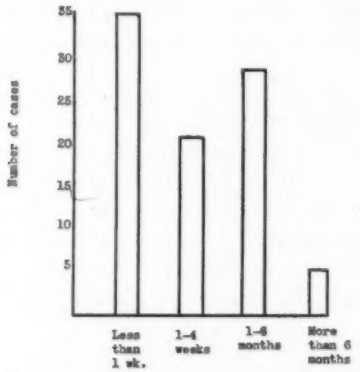


Fig. 4.—Duration of symptoms at the time of hospital admission.

The length of time which patients experienced symptoms before admission to the hospital is one of the most difficult factors to determine with any accuracy. A general grouping of the cases according to the length of this time interval is shown in Fig. 4. Analysis of these groups is of some interest. Thirty-four patients, as far as could be learned from the informants, had symptoms of less than one week before admission. Many of these were admitted within a few hours after a known trauma, usually followed by stupor or vomiting or associated with a fracture of the skull. These are easily understood. However, also in this group there are many patients who were brought to the hospital either during or shortly after a convulsive seizure and who, as far as can be ascertained from all informants, were perfectly well until the onset of the convulsion. This group is interesting because subsequent findings on clinical and pathologic examination frequently showed that clots must have been present for weeks or even months. In many of these infants there is never an acute phase which produces recognizably

abnormal behavior. The first symptom appears only after gradual expansion of the clot has been sufficient to reach a pressure necessary to produce a convulsion.

Twenty-one patients had symptoms referable to subdural hematoma for from one to four weeks when first seen. In this group are included many of the babies whose hematomas undoubtedly became established during the neonatal period as a result of birth trauma. A frequent triad seen during the first month of life includes (1) failure to do well, as evidenced by lack of normal weight gain, refusal of feedings, hyperirritability, or irregular temperature swings accompanied by (2) an accelerated increase in head size and (3) a history of difficult labor or delivery. This triad should arouse immediate suspicion of subdural hematoma and lead to appropriate investigation as soon as possible.

In general, it is the patients in these first two groups, that is, those who have hospital treatment started within one month of the first recognizable symptoms, who are apt to have the most favorable results. Unfortunately, this is not always true, because, as already noted, the hematomas may have been present for a long time with no apparent symptomatology.

Twenty-seven patients had symptoms from one to six months before hospitalization and five, for more than six months, the longest two in this series being eleven and fourteen months. The outlook in the patients in these groups becomes much graver. Of the five patients in the latter group, one died immediately following operation, extreme atrophy of the cortex being visualized at the time of operation; two are now symptom free but show gross mental deficiency; one did well for three months, beyond which no follow-up information is available; and the other, who had an associated abnormality of the cortical vessels, is well but has a hemiplegia and has had occasional convulsions.

SIGNS

The commonest physical findings exhibited by our patients with subdural hematoma are presented in Fig. 5. Since the history is so often inadequate and unreliable, careful observation of clinical signs becomes particularly important. Temperature irregularity was almost a constant feature, especially in the younger infants. Only about 10 per cent of our patients had a normal temperature on admission. The great majority, sixty-six patients, exhibited fever, and a smaller number, nineteen patients, showed a subnormal temperature. Infection elsewhere in the body was responsible, of course, for much of the fever.

It is difficult to make out many of the finer neurologic signs in patients of this age group. However, much can be learned from simply watching the baby's behavior and perhaps the most striking general feature to be observed is the hypertonicity. About two-thirds of the patients in our group were found by the original examiners to have hyperactive reflexes. Rigid or spastic extremities and ankle clonus were

common findings. Overactive responses to all types of stimuli were characteristic. Attempts at localization of this lesion to one side or the other on the basis of neurologic examination have been unsatisfactory.

At the time of admission, twenty-eight patients were noted on the records to have hydrocephalus. Some care should be taken here about terminology. Probably enlarged head would be a more accurate term to use for these patients, for hydrocephalus implies enlargement of the head due to abnormally large collections of spinal fluid either in the ventricular system or in the subarachnoid space, which these patients do not necessarily have. The lateral ventricles may become greatly dilated in the later stages of neglected hematomas, but this follows as a result of extensive cortical atrophy and obstruction to spinal fluid absorption.

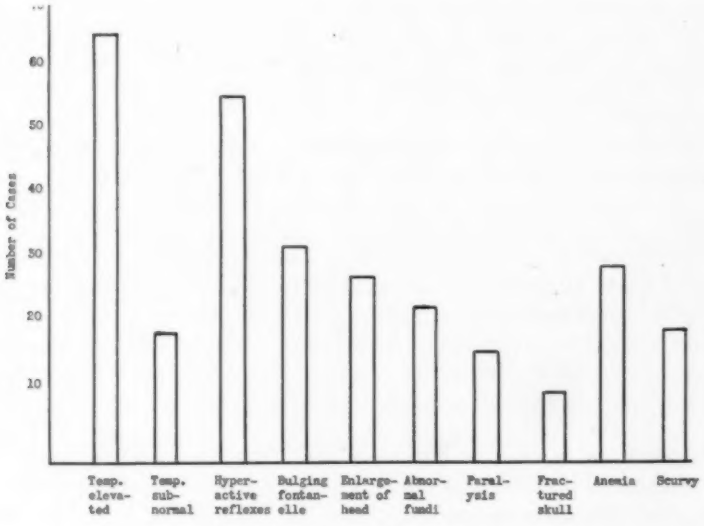


Fig. 5.—Common physical findings.

The enlarged head of subdural hematoma in infancy cannot be distinguished on clinical examination from the early stages of so-called idiopathic internal hydrocephalus or from hydrocephalus secondary to any sort of obstruction to the cerebrospinal fluid circulation. Frequently in subdural hematoma it seems that the principal enlargement is in the biparietal diameter, while in idiopathic hydrocephalus there is most marked increase in the fronto-occipital axis. However, this general impression cannot be relied upon. It is extremely important, therefore, to make a careful differentiation of the type of abnormal enlargement of the head because of the great difference in prognosis which is involved. The outlook in most forms of hydrocephalus is so poor and

the pessimism regarding treatment so widespread that investigation of these babies is likely to be neglected.

Among the infants who show abnormal enlargement of the head, the number due to subdural hematoma is small. In the Neurosurgical Clinic of The Children's Hospital, 310 patients have been seen with hydrocephalus since 1928. One hundred thirty-two of these conditions were associated with meningocele, leaving 178 due to other causes, as compared with twenty-eight babies having enlarged head due to subdural hematoma. However, the difference in outlook between these two groups is so great that in the early cases especially subdural hematoma must definitely be ruled in or out as soon as possible. Figs. 6 to 20 show admission photographs of typical infants with this lesion. The size and shape of the head and the position of the extremities especially should be noted.

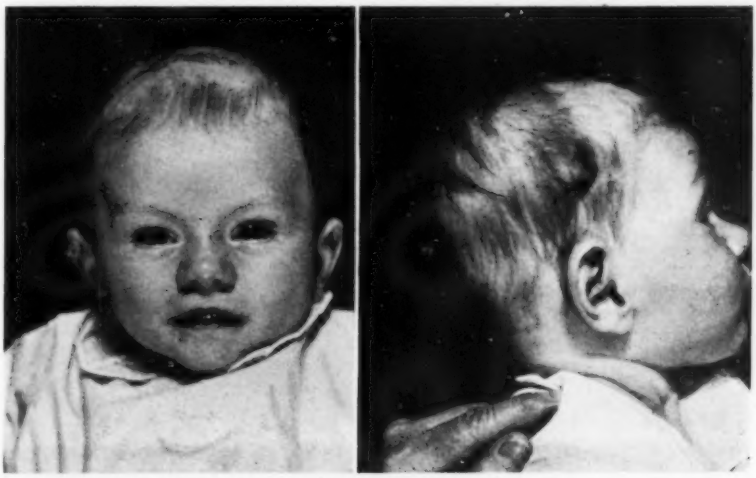


Fig. 6.—D. M., 6 months of age, fell from a three-foot table three weeks before admission. He was symptom-free until six days before admission, when irritability, fever, and pallor were noticed. Four days before entry, the infant began to vomit and have diarrhea. Physical examination showed a well-nourished infant with hyperactive deep tendon reflexes and bilateral ankle clonus. Subdural membrane was removed on the right side, and the patient was discharged on the eleventh postoperative day. Total hospital stay was six weeks. Follow-up for two and one-half years showed normal development.

Many of these patients also show the other phenomena which go along with increased intracranial pressure in the patients in this age group, that is, separation of the sutures, "cracked pot" percussion note in the skull, increase in size of the fontanels, bulging of the anterior fontanel, and turning downward of the eyes. Twenty-one of our patients showed abnormal fundi to ophthalmoscopic examination, the most common lesion being numerous small retinal hemorrhages. A few showed secondary optic atrophy. Papilledema, though seen occasionally, is rare in the children in this age group because of the decompression permitted by

Fig. 7.

Fig. 8.

Fig. 7.—W. D., 4 months of age, had a mass present on the right side of the head at birth which later calcified. He had a high, shrill cry but no convulsion, vomiting or paralysis. Physical examination showed a well-nourished infant with a calcified mass 3 by 4 cm. in the right parietal region. Lateral nystagmus was present bilaterally. Calcified hematoma was removed from the right subdural space, and the patient was discharged on the twenty-first postoperative day after recovery was complicated by acute otitis media. Total hospital stay was eight weeks. Follow-up for five years showed adequate mental development. There is still some nystagmus, but vision is apparently normal.

Fig. 8.—C. B., 7-month-old premature infant; 2½ pounds. Complaint, convulsions.

Fig. 9.—J. M., 5 months of age, had a normal birth history. A shrill cry was noted at 1 month of age. Generalized convulsions and enlargement of the head were first noted at 3 months of age. Physical examination showed a moderately well-nourished infant with an enlarged head and a wide fontanel. Both fundi showed blurring of the discs and retinal hemorrhages. Bilateral subdural membranes were established by burr holes. The postoperative course was complicated by pneumococcus pneumonia and otitis media which responded well to chemotherapy. Bilateral bone flaps were subsequently raised with removal of thick clots and well-organized membranes from both sides. Total hospital stay was two and one-half months. Follow-up for one and one-half years showed normal development and a negative physical examination.

Fig. 10.—F. L., 11 months of age. Irritability, weight loss, and increasing pallor were noted one month before entry, together with frequent vomiting. The patient had several generalized convulsions on the day before admission. Physical examination revealed a poorly nourished, pale, semistuporous infant with enlarged head, bulging fontanel, and numerous retinal hemorrhages. The general condition improved remarkably on daily subdural taps. The subdural membranes were subsequently removed bilaterally with uneventful convalescence. Total hospital stay was three months. Follow-up at 3 years showed a healthy child with apparently normal mental development (Fig. 37, *lower center*).

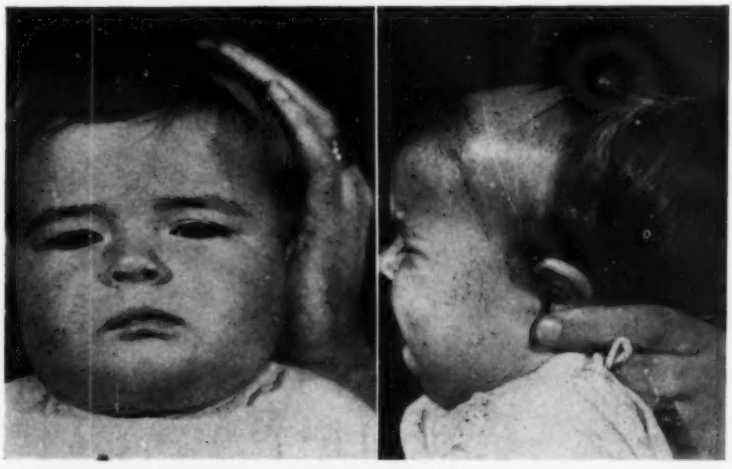


Fig. 11.—L. B., 6 months of age, fell from a high chair six days before entry, striking the back of the head. Vomiting, drowsiness, and irritability were noted for four days. Physical examination showed only a bulging fontanel and slightly hyperactive reflexes. Lumbar puncture showed xanthochromic fluid, and subdural taps showed grossly bloody fluid on both sides. Subdural taps were continued daily on alternate sides for three weeks Bilateral burr holes then revealed the absence of membranes, and the subdural space subsequently became completely dry. Total hospital stay was six weeks. Follow-up at 2½ years showed entirely normal mental development.

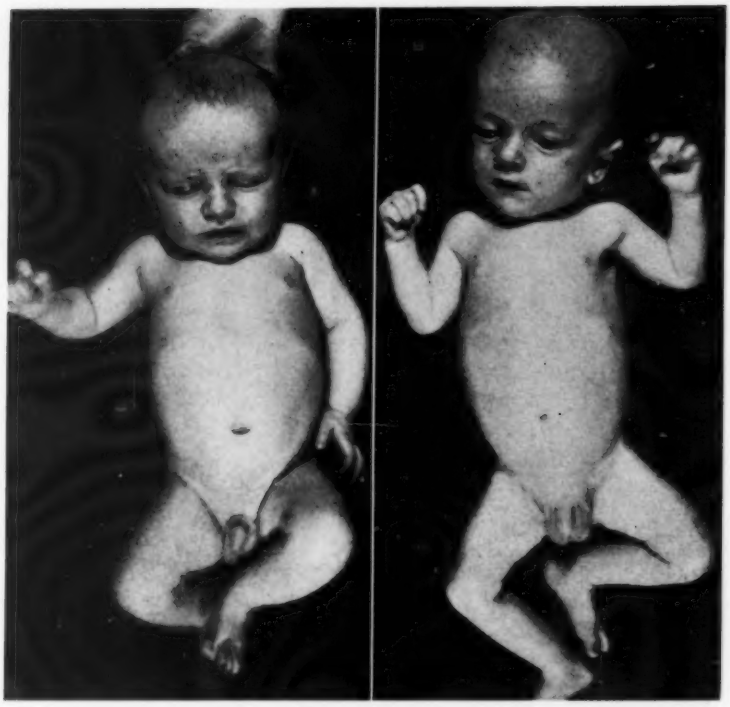


Fig. 12. Fig. 13.

Figs. 12 and 13.—*(For legends see opposite page.)*

Fig. 14.—*(For legend see opposite page.)*

Fig. 15.—N. D., 8 months of age, was admitted with vomiting, enlargement of head, and papilledema.

Fig. 16.—C. F., 2 months of age, had no history of trauma, but fracture of the skull was demonstrated by x-ray. There was vomiting, convulsions, and a temperature of 101.8° F.

Fig. 12.—R. G., 2 months of age. Stuporous on admission; generalized convulsions; bulging fontanel; retinal hemorrhages; temperature, 101° F.

Fig. 13.—R. H., 3 months of age, was born after a normal delivery after a ten-month gestation and an eleven-and-one-half-hour labor. Feedings were taken poorly from birth. The head was first noted to be abnormally large at 2 months of age. Four generalized convulsions between 1 and 3 months of age were noted. Physical examination showed an enlarged head with prominent veins, bulging fontanel, hyperactive reflexes, and spastic extremities. After preliminary tapping and burr holes, bilateral bone flaps with excision of subdural membranes were carried out, and the baby was discharged home in good condition. Total hospital stay was three and one-half months. Follow-up at 3½ years showed an asymptomatic apparently normal child.

Fig. 14.—T. W., 4 months of age, was admitted because of generalized convulsions.

separation of the sutures. Fifteen patients showed some form of paralysis, usually either facial palsy or hemiplegia.

It should be stressed again here that by no means do all babies with subdural hematomas have enlarged heads, nor do they all show the neurologic signs just discussed. Frequently the picture is simply that of an infant appearing acutely or chronically ill who may have an ele-

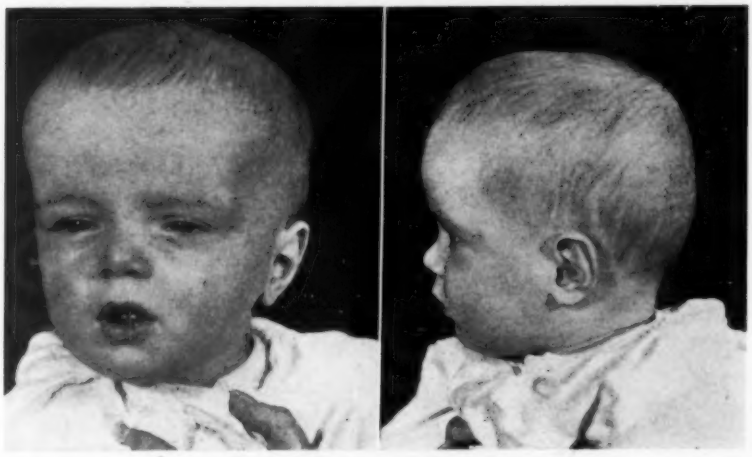


Fig. 17.—R. H., 5 months of age, had three slight convulsions during the two months preceding admission.

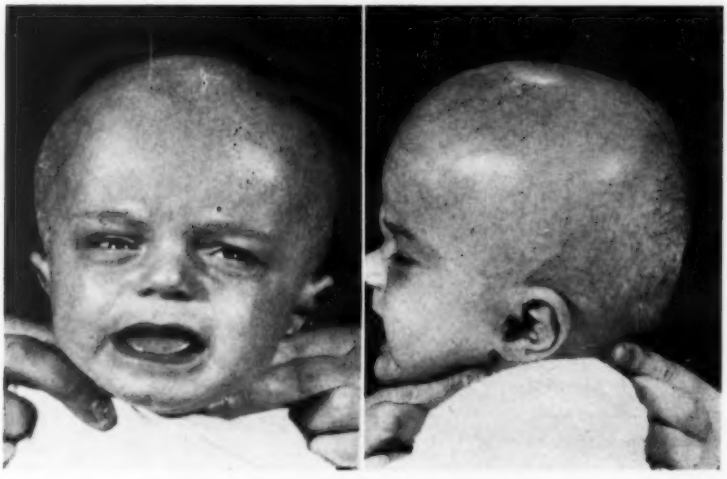


Fig. 18.—R. C., 5 months of age, had no history of trauma. Ecchymosis around the eye and fracture of the skull were demonstrated by x-ray.

Fig. 19.—*A*, D. P., was admitted because of convulsions. X-ray examination showed fracture of the arm and leg and marked bulging of the fontanel. *B*, Note skin lesion about mouth, presumably associated with dietary deficiency.

A.

B.

Fig. 19.—(*For legend see opposite page.*)

vated or a subnormal temperature and appear somewhat malnourished. Alertness to the possibility of hematoma giving rise to this picture will be well rewarded.

Fig. 20.—R. S., 7 months of age, had enlargement of the head and signs of increased pressure. (Incidental congenital syphilis.)

DIAGNOSIS

Laboratory studies are of little significance. Fig. 5 indicates that twenty-nine patients showed anemia; that is, red blood cell counts of less than 4,000,000. Twenty-nine more patients showed evidence of hemoconcentration undoubtedly due to dehydration as a result of vomiting, malnutrition, and infection.

X-ray studies do not usually help in making this diagnosis. Spreading of the sutures is seen, but this can be determined clinically. Only eleven of ninety-eight patients showed skull fractures by x-ray. Encephalography and ventriculography are unnecessary and are apt to be extremely disturbing to these infants. Few of them have been done in our series. In Fig. 21 is shown an encephalogram of an infant who had symptoms for more than three months. In addition to the dilatation of the ventricular system and marked cortical atrophy, the presence of the clot shows clearly on one side. Actually, this patient had bilateral clots of essentially the same size and age.

We have already stated that there is no way the diagnosis of subdural hematoma can be made definitely from a consideration of the history and physical examination alone. It never becomes accidentally apparent to the casual examiner in the course of the general investigation of an ill infant. The diagnosis can be established by puncture of

the subdural space and by this procedure alone. This implies that the lesion must be suspected and sought for, as there is no other indication for doing subdural puncture. Furthermore, as a result of this simple procedure, the diagnosis can be promptly and unequivocally made and treatment started with no further investigation necessary.

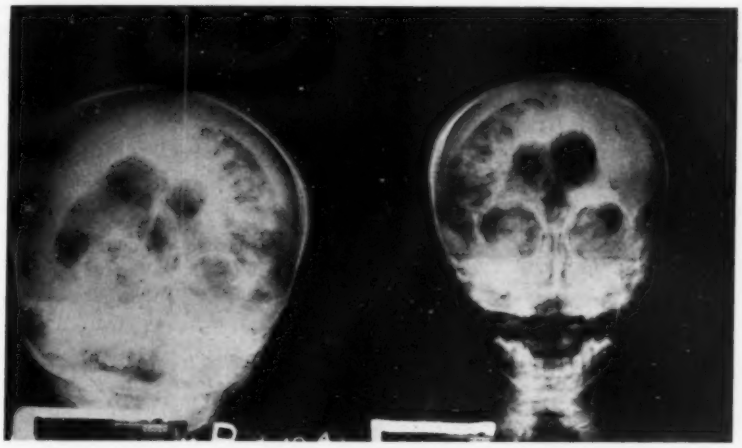


Fig. 21.—Encephalogram of patient who had clear-cut symptoms before admission. Clot shows clearly on the right. Note also cortical atrophy and enlargement of ventricles. Clots were actually bilateral.

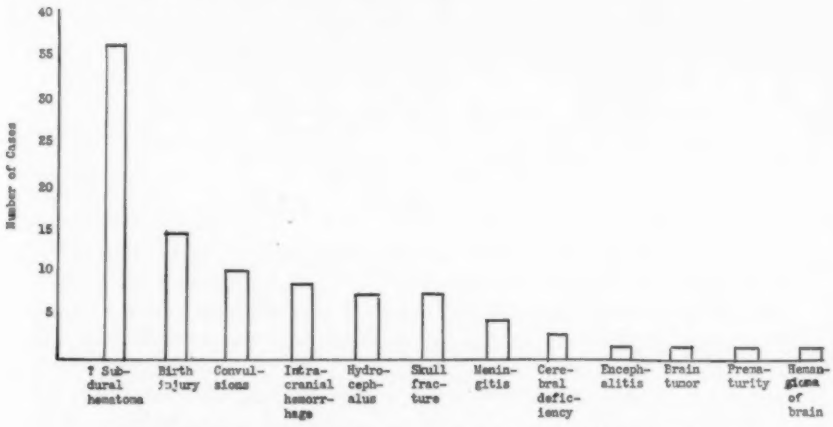


Fig. 22.—Primary admitting diagnosis (prior to subdural taps).

Fig. 22 is of some interest, as it tabulates the different diagnoses with which these infants were sent into the hospital by referring physicians or members of the staff who saw them in the outpatient department. It is evident that only about one-third entered the hospital with the correct primary diagnosis.

PATHOLOGY

In chronic subdural hematoma the pial veins have been generally accepted as the source of the hemorrhage. Theoretically, it could occur also from tears in the inner wall of the dural sinuses or possibly from the veins in the dura itself. The latter are closer to the outer than the inner surface of the dura and are so minute that it seems unlikely that they contribute significantly to this lesion. Evidence of tears in the longitudinal sinus has not been demonstrated in cases of chronic hematoma coming to post-mortem examination. The pial veins, however, which extend from the cortex to the lacunar spaces of the superior longitudinal sinus, are most exposed to stretching and rupture by the type of trauma which seems to give rise to subdural hematoma. The location of the clots formed is consistent with this origin, and occasionally in babies with acute cases this source of bleeding has been demonstrated at autopsy.

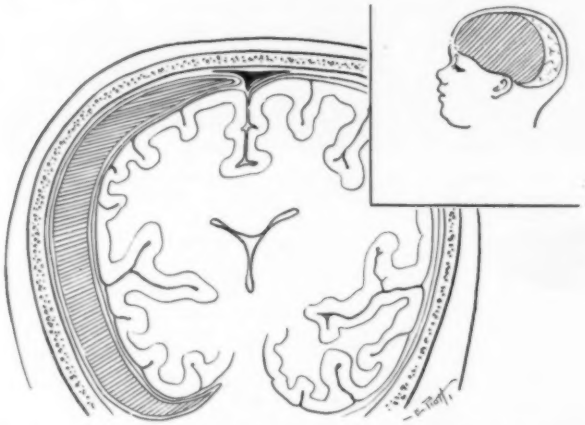


Fig. 23.—Diagrammatic sketch showing location and extent of clots.

The distribution of the clots as seen in the patients in our series has been almost constant and is illustrated in Fig. 23. In the chronic lesions where a membranous sac had been formed, it was found to extend from the posterior parietal region well forward over the frontal pole and from the longitudinal sinus superiorly to the floor of the frontal and middle fossae inferiorly. The occipital pole was the only portion of the cortical surface not involved. Diagnostic subdural taps or trephinations, therefore, should never be made in this region.

In infancy subdural bleeding is usually bilateral, although very often more severe on one side than the other. As seen in Table I, of the ninety-eight patients in this series, seventy-seven had bilateral hematomas and twenty-one, unilateral. Of the sixty-two patients who had definite membranes formed, thirty-two showed them on both sides. The

well-formed chronic hematomas are remarkably consistent in size also, suggesting that the amount of bleeding is limited by the capacity of the subdural space rather than by other factors; that is, oozing continues until sufficient pressure is built up to stop it.

The course of events in the formation of the chronic lesion, together with its gross and microscopic pathologic characteristics, has been discussed by many authors since the report of Putnam and Cushing in 1925.[12] The studies of Leary,[13] particularly, are now well known. There is no special reason, therefore, to elaborate on this here.

TABLE I

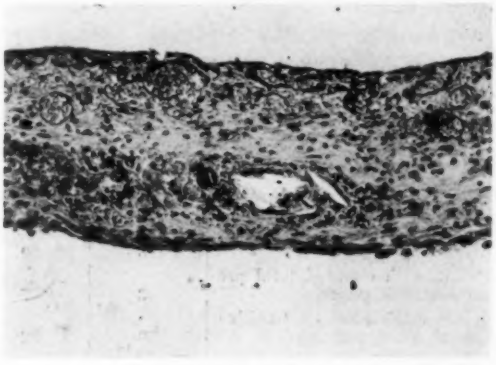
SUMMARY OF PATHOLOGIC FINDINGS

	UNILATERAL	BILATERAL	TOTAL
Grossly bloody or xanthochromic fluid found on subdural puncture	18	70	88
Excessive clear fluid with elevated total protein found on subdural puncture	3	7	10
Subdural membrane established by trephination and removed at craniotomy	30	32	62
Solid blood clot in addition to fluid still present in sac at the time of craniotomy	7	13	20

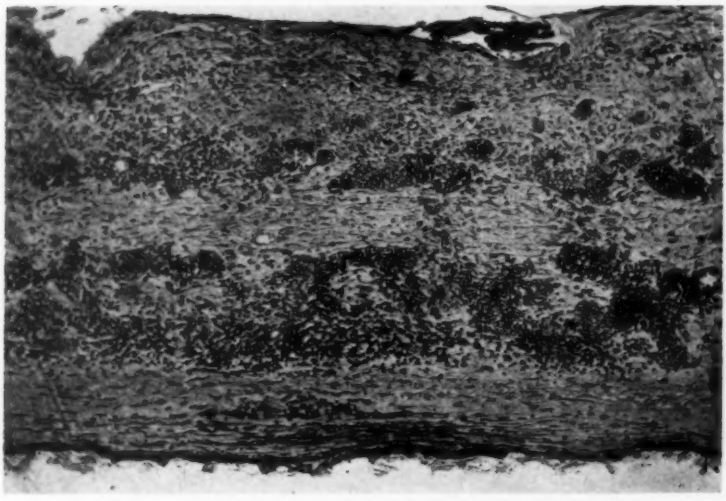
It is sufficient to recall that following a hemorrhage into the subdural space an attempt is made by the body to wall off the resultant clot from the dura on one side and from the arachnoid on the other. From the undersurface of the dura young fibroblasts grow out in profusion and, together with new capillaries, begin to invade the clot probably sometime during the first or second week. This granulation tissue brings in with it many histiocytes which engulf and carry away debris from the breakdown of corpuscles within the clot. At this stage it is closely adherent to the undersurface of the dura, and separation from the dura results in considerable ooze due to rupture of these new capillaries. As resorption of the clot continues, a xanthochromic, high protein fluid remains. The fibroblasts continue to proliferate, begin to lay down collagen, and take on the form of adult connective tissue cells. In the outer margin, that is, immediately under the dura, these cells tend to arrange themselves in a parallel fashion, giving rise to a definite membrane. This membrane then becomes more densely vascularized and thickened as time goes on, assuming the proportions of a well-developed structure separated from the dura.

From the edges of the clot the same granulation tissue which has early arisen from the dura advances underneath the clot, between it and the arachnoid, eventually forming a much thinner inner membrane. The arachnoid may contribute in part to the formation of the inner membrane, but there is never the close adherence that is seen between the outer membrane and the dura. In this manner, a complete membranous sac is formed, entirely isolating the clot and its breakdown products from the subarachnoid spaces.

It is well established now that the quantity of fluid within such a sac may increase without further bleeding. This occurs because the encapsulated high protein fluid acts by osmosis to draw in fluid from the outside through the wall of the sac, which acts as a semipermeable membrane. In a well-developed hematoma the outer membrane is from 1



A.



B.

Fig. 24 *A* and *B*.—Low-power photomicrographs of subdural hematomas showing organization and vascularization.

to 4 mm. in thickness and in the gross is a tough, inelastic, shiny, gray, vascularized structure. The inner membrane is much more filmy and transparent but may show well-developed blood vessels.

The contents of the hematoma sac vary, of course, according to the age of the hematoma and how early subdural taps have been started. There

is always considerable fluid which varies from light yellow in color to a deep bluish green hue. Occasionally in infants the fluid may be quite colorless and clear but with an elevated total protein content. Solid clot may be present in all stages from bright red in color with jellylike consistency to old grayish, friable masses of fibrin.

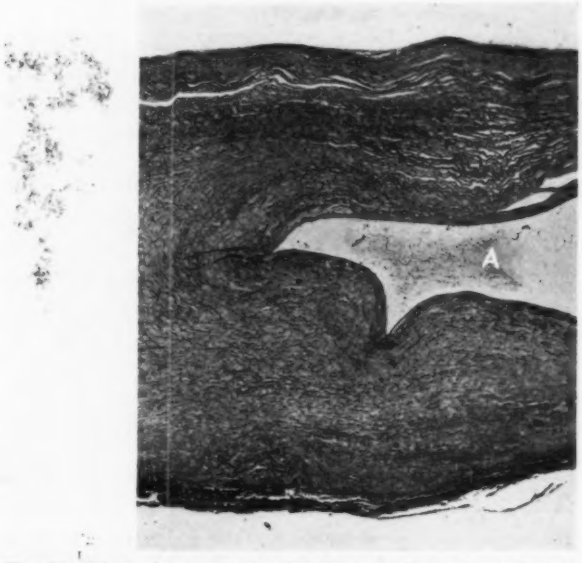


Fig. 25.—Photomicrograph showing inner surface of membrane above, outer surface below. Note sac (*A*) containing blood-stained fluid. There are no endothelial cells lining this sac.

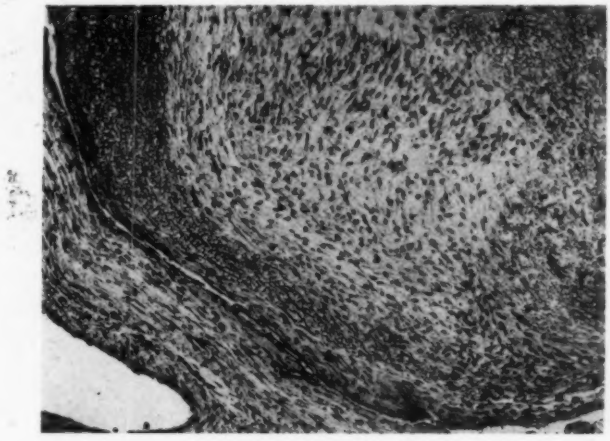


Fig. 26.—Photomicrograph showing marked degree of organization typical of outer membrane.

If punctures have been started early, no solid clot may form at all, and at operation a rather thin but nevertheless inelastic tough membrane will be found with an excess of fluid or, more rarely, a normal amount of fluid. It may be impossible under such circumstances to demonstrate separate outer and inner membranes. Figs. 24, *A* and *B*, 25, 26, 27, and 28 show typical membranes in cross section at different stages.

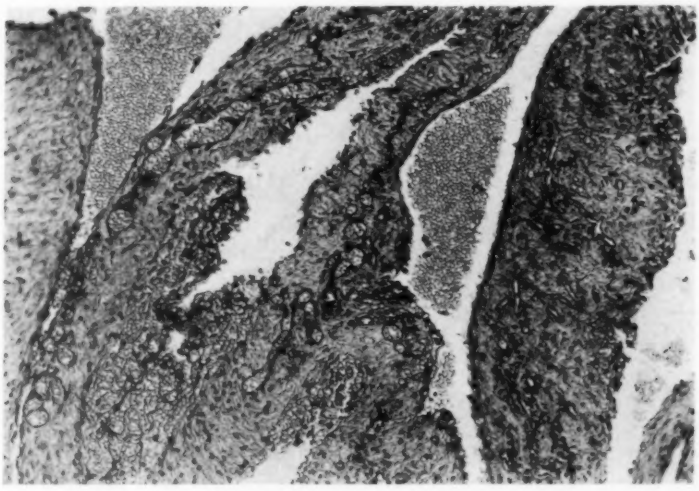


Fig. 27.—Photomicrograph showing well-organized and highly vascularized membrane showing spaces filled with old blood and fibrinous debris. The membrane is folded on itself.

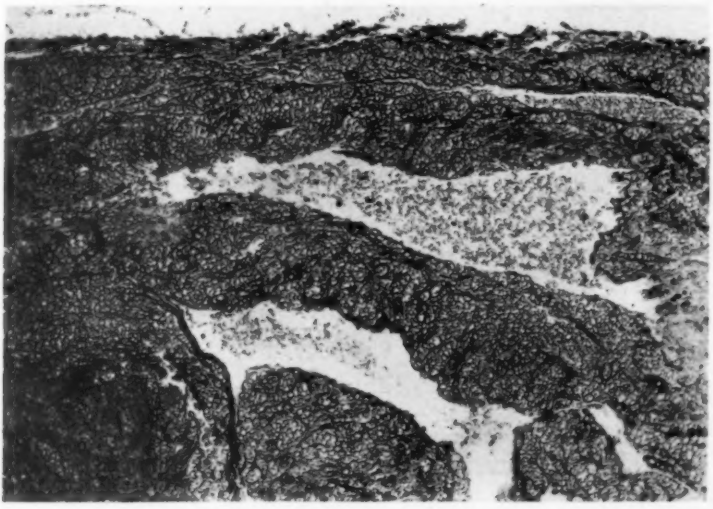


Fig. 28.—Same patient as in Fig. 27. Photomicrograph showing an area of greater degeneration of the clot and less advanced organization.

Associated with chronic subdural hematoma in infants in this age group certain other pathologic changes are seen. The dura itself is likely to be somewhat thicker than normal and is usually abnormally vascular. The underlying arachnoid becomes thickened, translucent, and grayish. Atrophy of the convolutions with deepened sulci and dilatation of the lateral ventricles ensues in rough proportion to the length of time the clot has been present. Microscopic sections of cortex underneath a clot show no pathologic changes, except when there has been long, continual pressure. A summary of the pathologic findings in our series is made in Table I.

TREATMENT

During the first three months of life the brain volume is approximately doubled. In the next six months it is doubled again. On this simple anatomical fact is based a fundamental difference in the plan of treatment generally applicable for subdural hematoma in infants and in adults. In patients in the adult age group it has been found that evacuation of fluid and clotted blood by means of suction and irrigation through one or more burr holes or through a small decompressive opening has usually been sufficient to relieve symptoms. In adults the important thing has been to remove the space-occupying material which has exerted a compressive effect on the cortex. The presence of a residual membrane has usually been insignificant as long as pressure on the underlying brain was eliminated. Occasionally, in a large chronic hematoma in an adult, the outer and inner membranes may become so thickened and highly organized that evacuation of the sac is not followed by its collapse and re-expansion of the brain. In these patients symptoms may persist and necessitate elevation of a bone flap for removal of the membrane.

In infancy simple evacuation of the space-occupying components of the hematoma is not sufficient. The hematoma membrane which forms from the undersurface of the dura, even though very thin, is an inelastic connective tissue structure similar to scar tissue anywhere in the body. Because of this it restricts the rapid expansion of the brain which is taking place during this period and, by so doing, impairs the development of cortical functions which are being elaborated coincidentally. Cortical blood supply from the pial vessels is apparently embarrassed as is absorption of spinal fluid due to compression of the subarachnoid space. Spinal fluid absorption is probably also diminished by chronic inflammatory reaction in the arachnoid resulting from blood in the subarachnoid and subdural spaces.

The pathologic physiology of this disease, therefore, during the first two years of life is quite different from that after the brain has achieved its full growth. It seems to us entirely reasonable that the treatment should vary accordingly. The argument is simple and comes down to the fundamental conclusion that in infancy subdural membranes must

be removed or at least widely decompressed if normal development and function of the cerebral cortex is to be preserved.

Naffziger and Brown stated in 1934[6] that in their experience sudden release of the content of the subdural hematoma sacs with resulting alteration in the intracranial pressure relationships was not tolerated well by infants. This was also found to be true in the early cases seen at The Children's Hospital. When first brought to the hospital, the general condition of these infants is usually so poor that the elevation of an osteoplastic flap for removal of a solid clot or membrane is out of the question. Their status is apt to be so precarious that any disturbance of circulatory dynamics such as would be incident to craniotomy in infants in this age group would almost certainly be fatal.

Just as a sudden operative decompression at this stage is not indicated, so also attempts to aspirate all the contents of the hematomas by subdural puncture, or even to remove a very large quantity of fluid at one time, should be avoided. Disproportion between the capacity of the cranium and the volume of the intracranial contents may be quite remarkable if large bilateral hematomas in infants are suddenly evacuated. The sudden removal of compression over the cortex with resultant marked alteration in intracranial pressure relationships may give rise to an acute cerebral edema which can be fatal and certainly is not well tolerated by an already unstable infant.

Some method of more gradual release of pressure is essential. However, as already pointed out, at least partial decompression cannot be long delayed if permanent damage to the cortex is to be avoided. Consequently, a combination of early conservative and ultimate radical treatment of these lesions would seem to give the most hopeful outlook. The mortality has been high in those infants treated by immediate radical operation, on the one hand, and the incapacitating sequelae, especially in the form of mental retardation, all too frequent in those treated conservatively on the other.

The plan of treatment which has been developed at The Children's Hospital, therefore, and used routinely since 1937, provides this combination of early conservative and eventual radical surgical therapy which appears to be so desirable. We feel that the results of this careful, rather tedious and prolonged plan of treatment justify its continuation and have improved substantially the outlook in a situation hitherto so unsatisfactory. Because attention to detail appears to be of considerable importance in the results achieved, the steps in the care of these patients will be outlined at some length.

Subdural Taps.—We have already stressed the importance of subdural puncture in making the diagnosis of this lesion. Such a diagnostic puncture also constitutes the beginning of treatment. There is so much to be gained by the earliest possible commencement of treatment that subdural taps should never be delayed once the diagnosis is suspected.

In the hundreds of taps done routinely by members of the house staff of The Children's Hospital, there has been almost complete absence of complications as far as we are aware. This is probably due, at least in part, to the insistence on a fairly exact routine. Frequently twenty or more taps have been done on one infant over periods of as long as three weeks without infection or other untoward sequelae. Although tapping the subdural space is an extremely simple procedure, many questions arise among those who are not acquainted with it, so our technique is presented in detail. We believe that it should not be taken too lightly but is entirely safe if carefully executed. The strictest asepsis is observed, as such a stagnant collection of blood must provide an excellent culture medium and the consequences of infection in this location are most critical (Fig. 29).

Fig. 29.—Standard kit for subdural tap and lumbar puncture, including alcohol and zephiran for skin preparation, novocain, and short-beveled needles.

The infant should be wrapped in a restraining blanket or sheet so that the arms and legs are completely immobilized. With the baby lying on his back, a nurse holds the sides of the head with her hands placed in such a fashion as to keep the baby's face uppermost and the head as immobile as possible. A rubber nipple stuffed with cotton saturated with glucose solution will aid materially in quieting the patient (Fig. 30). The field should be widely exposed and prepared. This includes shaving all the hair anterior to a line extending between the ears. It is a mistake to shave only a small area at the site of the proposed puncture,

since this not only obscures landmarks, but also incurs an unwarranted risk of infection. After shaving, the field is prepared as thoroughly as any operative field with a suitable skin antiseptic. Sterile towels are used to isolate the field. The operator should always use sterile gloves.

By palpation through a layer of sterile gauze the sites for the proposed punctures are selected in the frontal suture line well beyond the lateral margins of the anterior fontanel, as shown in Fig. 30. One per cent novocain is used to make a wheal in the skin. Together with the glucose nipple this produces sufficient anesthesia for the procedure. The novocain also controls any bleeding from the scalp. No. 19 or No. 20 short bevel lumbar puncture needles that are about two inches in length and equipped with accurately fitting stilettes are used. The needle is inserted through the skin wheal at right angles to the scalp and

Fig. 30.—Needle draining fluid from left subdural space. Note novocain wheal at site of right tap.

its progress carefully controlled by holding the shaft with the thumb and forefinger of the left hand as illustrated. This hand rests gently against the top of the baby's head. With very little experience it is possible to tell when the needle penetrates the scalp and dura. When it goes through the dura a definite sense of resistance is suddenly overcome.

Under normal circumstances, from several drops up to 1 c.c. of clear, colorless fluid with a total protein content of from 15 to 30 mg. per 100 c.c. can be obtained from the subdural space. More than this amount is pathologic. Normally, the subdural space, therefore, is really just a potential one, so if there is any collection of fluid there it must be under some pressure and will flow readily through a needle. If the pressure

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Fig. 31.—Characteristic color of fluid at the time of removal.

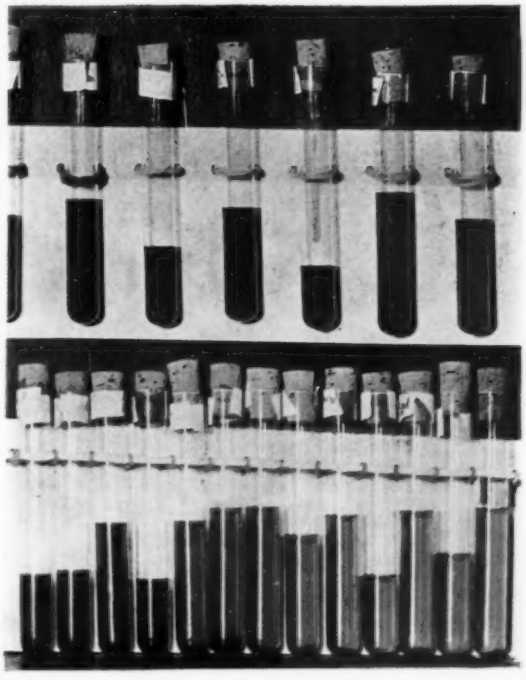


Fig. 32.—Change in character of fluid as taps are repeated over a period of days.

is great, it may actually spurt from the needle on removal of the stilette. It may be necessary to wait a moment or two and to adjust the needle by rotating it in order to start the flow. A syringe is not attached to the needle and aspiration is contraindicated. During this and subsequent parts of the procedure, the operator must continue to hold the shaft of the needle firmly at the skin surface to prevent lateral movement of the point. If fluid is present it will be encountered immediately beneath the dura. The needle should not be advanced beyond this point if no fluid is encountered and the operator is sure the dura has been penetrated.

Subdural taps are customarily done on both sides at the first sitting. If bilateral hematomas are present, from 10 to 15 c.c. of fluid are removed from each side. This fluid is apt to be grossly bloody but will not clot on standing, and the supernatant fluid will be xanthochromic with an elevated total protein. Subsequent taps are routinely carried out daily on alternate sides with removal again of from 10 to 15 c.c. each time. We frequently keep these daily samples dated on a rack at the patient's bedside so as to follow readily the changes in the character of the fluid (Figs. 31 and 32). Typically, the number of red cells gradually decreases and the xanthochromia and total protein of the supernatant fluid increases. It is wise to culture the fluid every two or three days and institute chemotherapy at any suggestion of infection. Sterile gauze dressings should be kept over the sites of the punctures at all times. The actual point of skin puncture should be changed frequently so that repeated use of the same site does not make a wound large enough to permit leakage of subdural fluid in between punctures. Flexible collodion dressings are not recommended where repeated punctures are contemplated.

At the time of the original subdural taps a diagnostic lumbar puncture is also done. If this fluid is bloody or xanthochromic, indicating associated subarachnoid hemorrhage, daily lumbar punctures are carried out until the fluid is clear. If the original spinal fluid is clear, lumbar puncture is not repeated.

The daily taps are continued for a period usually of from one to two weeks, thus achieving a gradual decompression of the subdural space. During this time considerable attention is given to general supportive treatment of the infant. Often enough, following the first puncture, the condition improves remarkably. The infant is likely to become much more alert, less irritable and hypertonic, and most important, to take feedings much more readily without vomiting. The baby is fed with special care and is given additional fluids in the form of 5 or 10 per cent dextrose in water intravenously and normal saline or 2½ per cent dextrose in one-half normal saline subcutaneously. Small transfusions are given as indicated for anemia. If there is depression of the plasma proteins, transfusions of whole blood or plasma are used. The scalp veins are avoided in giving intravenous therapy where later craniot-

omy is contemplated. All of these infants are also given added vitamins in large doses. Foci of infection which may be present are treated as indicated.

On this conservative, yet intensive, therapy most of these infants improve rapidly and by the end of one or two weeks are gaining in weight steadily, are normally hydrated, and present an adequate blood picture. The next stage in treatment can then be carried out.

Bilateral Burr Holes.—In all patients where excessive subdural fluid has been demonstrated by subdural taps, bilateral trephination is carried out in the temporal region. This is usually done on both sides at one operation and ordinarily disturbs the patient very little. The burr hole is made through a short vertical incision in the temporal muscle in line with the external auditory meatus (Fig. 33). At this time the subdural fluid is evacuated as completely as possible by suction and irrigation.

Fig. 33.—Diagrammatic sketch showing location of incisions for burr hole and bone flap.

The primary purpose of this step, however, is to establish the existence of solid clot and the presence or absence of a membrane. The membrane may be quite filmy or considerably thicker than the dura itself. Both outer and inner membranes can be identified if the sac is an old one. The outer membrane is usually seen as a tough, shiny, gray, vascularized structure closely adherent to the undersurface of the dura. The burr hole wounds are closed tightly and usually heal very rapidly.

We prefer to carry out this procedure under drop ether anesthesia and do both sides at one time. Occasionally, if the infant is especially frail or his condition becomes precarious during the procedure, only one side is done at a time. In any case, it should be carried out quickly, as these infants do not tolerate prolonged anesthesia or manipulation. Anesthesia is often commenced directly on the operating table with preparations for operation completed so that all delay will be avoided. The anesthesia should be light throughout.

About one-third of our patients did well with repeated subdural taps, and membranes were never established. We wish to emphasize, however, that the only way this can be proved is by doing bilateral burr holes. If the presence of a membrane has been established, then the third stage in this plan of treatment is carried out. In the meantime, supportive therapy is continued, usually with progressive improvement in the infant's general condition.

Bone Flaps.—Usually from seven to ten days after the burr holes have been made, the baby's general condition warrants going ahead with the bone flaps. One side only is done at a time. A medium sized fronto-temporo-parietal osteoplastic bone flap is elevated, placed as shown in Fig. 33. No attempt is made to place the flap so as to conform to the complete distribution of the clot, and as a rule its margins are not exposed by a flap of this size. We are careful to place the anterior limb of the flap behind the hairline.

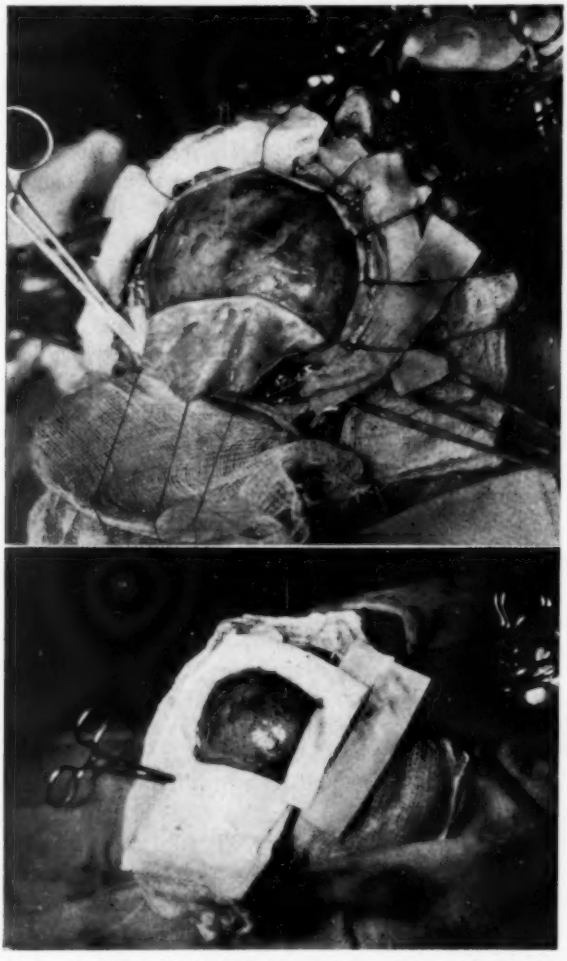
Here again, the operative procedure must be carried out as expeditiously as possible and with a minimum of trauma and blood loss. The younger infants are particularly apt to suffer considerable loss of body heat with rather sudden drops in temperature to as low as 96 or even 95° F. This should be anticipated and external heat in the form of warm blankets and hot water bottles applied as the operation proceeds. Recently we have found it of great convenience to use a thermocouple left in the rectum throughout the operation and the early postoperative period which records the temperature continuously and allows us to take appropriate measures early.

Before general anesthesia is commenced, a cannula is tied into a suitable vein, usually the internal saphenous, under novocain infiltration. An infusion of 5 per cent dextrose in saline is run in slowly throughout the operation, and whole blood is given usually by the time the closure is started, or sooner if the situation demands it. Intravenous stimulants which may occasionally be necessary can also be given readily by this route. We feel certain that craniotomy in infants in this age group for this lesion should not be attempted without all of these preparations.

The bone flap is elevated in the routine fashion. Often it is possible to cut the bone between the burr holes with stout scissors and save some operating time. The dura is incised in a circular fashion and, when raised, reveals the outer membrane of the hematoma, usually extending across the entire exposed field. Often the outer membrane is closely adherent to the undersurface of the dura and is more easily managed by blunt separation from the dura after the two have been raised together. The hematoma sac may be as much as three-quarters of an inch in thickness or it may be represented by a simple membrane from 1 to 2 mm. in thickness with almost no remaining fluid.

After raising the dural flap, all solid clot is removed by suction, irrigation, and gently lifting it out with blunt forceps. The outer mem-

brane, which is easily mobilized from the undersurface of the dura, is removed to the limits of the dural opening and occasionally a short distance beyond this anteriorly by careful dissection underneath the margins. No attempt is made to remove it entirely, as this is not necessary and, with this type of exposure, not technically feasible. The inner



A.

B.

Fig. 34 *A* and *B*.—*A*, Thick clot in situ, adherent dura being reflected; *B*, shows clot with dura reflected.

membrane varies a good deal, and if treatment has been started early in the course of the disease, the inner membrane may be very thin. In any case, it should be removed as carefully and thoroughly as possible from the cortex to the limits of the exposure. If the membrane is densely ad-

herent to the cortex, as is rarely the case, islands of it may be left behind rather than risk damage to the cortex, but it is extremely important to break up the continuity of the membrane as completely as possible to effect a wide decompression.

C.

D.

Fig. 34 *C* and *D.*—*C*, Outer membrane partially removed; *D*, inner and outer membranes removed, cortex exposed. Note deep subdural space.

A large cavity may be left at this stage. It has sometimes been possible to see the surface of the brain from frontal to occipital pole and from falx to the floor of the frontal and middle fossa when evacuation of the hematoma has been completed. This large space is filled with physiologic saline solution as the dura is rapidly closed. The bone flap is replaced and held in position by two or three silk stitches passed through its margins. The scalp flap is closed tightly in two layers without

drainage. Figs. 34, *A, B, C,* and *D,* and 35, *A* and *B,* show the bulging, tense, discolored dura after elevation of the bone flap, the appearance of the membrane, thickness of the clot, and size of the cavity remaining after its evacuation in typical cases.

Although the operation can be carried out in a relatively short time, one must be prepared for rapid changes in the patient's condition. Should signs of collapse, such as poor color, shallow respiration, thready pulse, or drop in temperature (shown by continuous recording apparatus) supervene, action must be taken immediately. At the first suggestion of such a change, external heat is applied, transfusion started, and ether anesthesia discontinued, with substitution of oxygen inhalation. Stimulants, chiefly coramine and caffeine, are judiciously used and the bone flap quickly replaced. If these measures are carried out promptly, the patient is soon restored to a satisfactory balance, but if there is any delay, all efforts at revival may be in vain. For this reason the cannula must be tied securely in the ankle vein and fluid must be kept running freely, although slowly, through it during the entire operation.

There are no particular complications of the postoperative period. Fluids are given by mouth immediately on awakening, and this, together with very small doses of aspirin or, less often, phenobarbital, usually constitutes sufficient sedation. If the operation is completed without untoward event, a single transfusion of 10 c.c. of blood per pound of body weight is usually sufficient. Scalp wounds in infants in this age group heal rapidly and solidly if there is no increase in intracranial pressure. Head dressings must not be tight, as pressure necrosis of the thin scalp over frontal and occipital prominences is very quick to develop.

If bilateral hematomas are present, craniotomy may be carried out on the second side in the same fashion in seven or eight days, or whenever the baby's general condition warrants. The total period of treatment of an infant with bilateral hematomas according to this plan is a long one. It usually means at least five or six weeks of hospitalization, at least three operative procedures under general anesthesia, and anywhere from two to six small transfusions. In the presence of infection, either locally or at some distant focus, the duration of treatment naturally may be prolonged considerably. However, it is usually an encouraging procedure because there is almost always continued improvement from the time that treatment is initiated with the first subdural puncture. Fig. 36 shows a patient two weeks after the second bone flap had been turned down.

Of the ninety-eight patients who had a positive diagnosis made by subdural puncture during the six-year period covered by this report, ninety-four subsequently had bilateral burr holes performed. Thirty-

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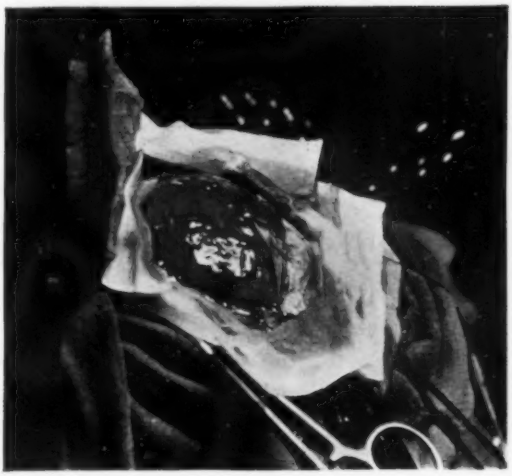

A.

B.

Fig. 35.—T. W. *A*, Dura reflected, clot in situ; *B*, same clot in process of removal with cortex exposed.

two of these patients had bilateral bone flaps elevated, and thirty had this operation performed on one side only, making a total of ninety-four craniotomies for removal of subdural membranes in sixty-two patients.

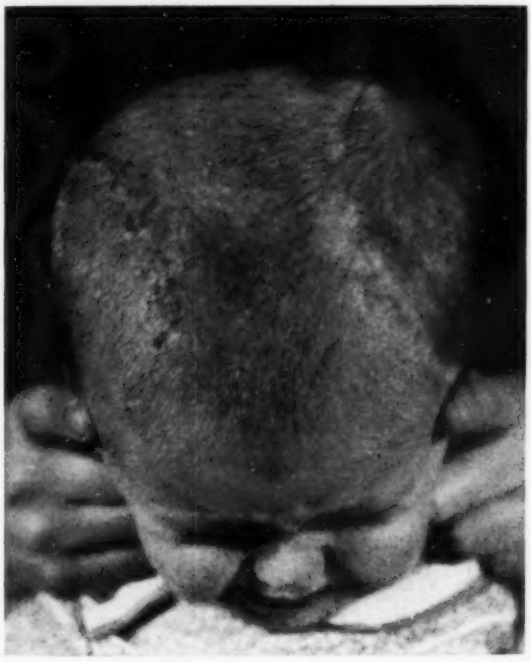

Fig. 36.—B. H. Shows patient two weeks after second bone flap had been turned down.

RESULTS

Of the ninety-eight patients with subdural hematoma in our series, nine died in the hospital. Fifty-seven have been followed adequately for a period of at least six months. The others have been either too recently discharged from the hospital or lack sufficient follow-up data to warrant adequate appraisal of their situation.

The nine hospital deaths are accounted for as follows: one was a very badly damaged infant who had diagnostic subdural taps performed but succumbed before any further therapeutic procedures were carried out. Three patients died following craniotomy or subtemporal decompression during the acute phase of bleeding and thus had none of the preliminary procedures recommended in this paper. Two more of the deaths occurred as a result of complicating sepsis, staphylococcus meningitis in one case and staphylococcus meningitis, epidural abscess, and osteomyelitis of the skull in the other. This leaves three patients since 1937 who represent operative deaths in uncomplicated cases. All three of these deaths occurred subsequent to the second craniotomy in in-

Fig. 37.—A group of apparently normal children, all of whom have had operative removal of subdural hematomas.

stances of bilateral hematomas, and all three patients showed marked cortical atrophy at the time of operation. Including postoperative hospital deaths from all causes, this gives an operative mortality for the ninety-four craniotomies performed of 5.3 per cent and a case mortality of 7.9 per cent.

While the number of patients who have been treated under the present plan is steadily increasing, the long-term follow-ups are few. Since the present form of treatment was not really adopted until 1937, the longest follow-up is five years. We fully realize that the accuracy of any appraisal of mental development in this short time is questionable. However, evaluation of mental age and the general ability to cope with the normal problems of environment can be made to a fair degree of accuracy by persons trained in this work and to some extent by any careful observer.

Of the fifty-seven patients who have been adequately followed for more than six months (forty-three of these from 1 to 5 years of age) thirteen, or 23 per cent, are retarded, some of them being grossly defective. Forty-four patients, or 77 per cent, are not only greatly improved, but also show no outward evidence of cerebral deficiency. That is, their behavior as far as can be determined appears to be entirely normal for children of their age. Obviously, an accurate estimation of mental development cannot be made without repeated examinations over a number of years. For this reason an effort is being made to follow these cases carefully for as long as possible. A group of these apparently normal children is shown in Fig. 37.

Other criteria of the efficiency of treatment are of some interest. Of the fifteen patients who had some form of paralysis on admission, two have maintained a persistent hemiplegia and two, facial palsy. Many have continued to show very active deep tendon reflexes and even unsustained ankle clonus for varying periods of time, but the spastic extremities and excessive hypertonicity seen so frequently on admission usually disappears quickly and completely. Two patients who were apparently blind when first seen did not regain any vision postoperatively. In both there was visible optic atrophy before treatment was started. Of the twenty-eight patients seen with some degree of hydrocephalus before treatment, only one has shown progression of this picture following operation. This patient has just recently re-entered the hospital three months after removal of a membrane, and ventriculography now shows enormous symmetrical dilatation of the lateral ventricles, the etiology of which is not at all clear and may be entirely unrelated.

A residual complication which one might reasonably expect with some frequency is the occurrence of convulsive seizures since adherent hematoma membrane may have been left in place. Nevertheless, postoperative convulsions have been rare. Only seven patients have reported seizures since leaving the hospital, and in two of these associated abnormalities of the cortical vessels had been observed at craniotomy.

SUMMARY AND CONCLUSIONS

Subdural hematoma during infancy is a common lesion. It is most frequently seen in the first six months of life.

Trauma to the head is probably always a factor in the etiology of this lesion. The presence of systemic disease causing increased capillary permeability may materially lessen the severity of injury necessary. The possibility of hematoma as a diagnosis should never be ruled out because of the absence of a history of trauma.

There is no special clinical picture which is reliable in establishing the diagnosis. Generalized symptoms such as fever, vomiting, hyperirritability, and failure to gain in weight are frequently found alone or in addition to the more specific neurologic findings of convulsions, stupor, and paralysis.

Infants who show early abnormal enlargement of the head should never be abandoned as having incurable hydrocephalus until subdural hematoma has been ruled out.

The diagnosis can be made with certainty by bilateral puncture of the subdural space and by this method alone. A simple routine for carrying out this procedure safely is presented in detail.

The rapid increase in brain volume during the first two years of life must be unrestricted to insure the normal mental development of a child. Therefore, radical craniotomy with excision or wide decompression of constricting subdural membranes is essential if cerebral deficiency is to be avoided.

Infants during the first two years of life will tolerate radical surgery well for this lesion if proper preliminary measures and supportive treatment are undertaken. The plan of therapy used at The Children's Hospital since 1937 is discussed fully.

During the last six years, ninety-eight patients have had the diagnosis made by subdural puncture. In ninety-four of these, bilateral temporal burr holes were made. Sixty-two patients showed subdural membranes on one or both sides. Ninety-four craniotomies were performed with an operative mortality of 5.3 per cent and a case mortality of 7.9 per cent.

Of the fifty-seven patients who have been adequately followed for periods of from 6 months up to 5 years of age, 23 per cent are retarded or grossly deficient and 77 per cent are not only asymptomatic but show normal behavior for their age.

These results, it is felt, have sufficiently improved the outlook in subdural hematoma to call for a more diligent search for these infants. They also justify the prolonged hospitalization and radical surgical treatment that has been employed.

The frequency with which subdural hematoma is found in infancy is proportional to the intensity with which it is sought. Whereas treat-

ment is fundamentally a neurosurgical problem, suspicion of the diagnosis must rest primarily with the pediatrician and the general practitioner.

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THE ETIOLOGY OF CONGENITAL CEREBRAL PALSY

A Statistical and Clinical Study

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FROM the time of the original description of congenital cerebral palsy by Little in 1853 until almost the end of the second decade of this century, the consensus of medical opinion as to causation stressed the influence of various factors acting during birth on the central nervous system. During the last twenty-five years, however, there has accumulated an increasing body of literature opposing this conception of birth trauma as the prime etiologic factor. The evidence presented depended primarily upon the results of occasional post-mortem examinations which failed to show the findings that might be expected in cases of birth trauma as well as upon the high incidence of essentially normal birth histories in these cases.

The purpose of the present communication is to present a summary of the statistical analysis of the cases of eighty-six patients in whom the diagnosis of congenital cerebral palsy was made. The data throw light on the major importance of developmental cerebral defects in the etiology of the condition as well as on certain genetic relationships.

The cases to be discussed represent approximately 8 per cent of all patients admitted to Southbury Training School since its opening in October, 1940. The data were obtained from three sources; namely, personal interviews with parents at the institution, home visits by trained social workers, and records from hospitals and institutions in which the patients were previously confined. The statistical methods used were those described by Penrose[9] and Murphy.[7]

For our purposes we have defined congenital cerebral palsy as a motor defect present or appearing soon after birth and dependent on pathologic abnormalities in the brain. This rules out motor defects due to anatomical lesions in the cord, peripheral nerves, or muscles.

RESULTS

The data are summarized in the tables. Table I shows the distribution of cases according to the nature and extent of the neurologic involvement of the patients. Eighty-four per cent of the patients exhibited spasticity associated with one or more of the usual pyramidal tract signs, including increased deep reflexes, ankle or patellar clonus,

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TABLE I

THE DISTRIBUTION OF CASES ACCORDING TO NATURE AND EXTENT OF THE NEUROLOGIC INVOLVEMENT OF THE PATIENT

PYRAMIDAL (72)	STRIATAL (14)	CEREBELLAR (13)
a. Diplegia (47)	a. Uncomplicated (1)	a. Uncomplicated (8)
b. Hemiplegia (20)	b. Diplegia (8)	b. Striatal (5)
c. Quadriplegia (3)	c. Cerebellar (5)	
d. Triplegia (1)		
e. Monoplegia (1)		

extensor Babinski response, and absent abdominal or cremasteric reflexes. Of these, patients with diplegia comprised the major clinical group. The diagnosis of spastic diplegia was confined to those showing bilateral symmetrical involvement of both upper and lower extremities, most marked in the lower. The condition of those with quadriplegia was differentiated by involvement of all four extremities in a more irregular manner, with equal or greater spasticity in the arms. There were fourteen patients with choreo-athetosis, the condition of only one being uncomplicated. In addition to choreo-athetosis, the others showed either diplegia or definite cerebellar dysfunction. There were eight patients with uncomplicated cerebellar ataxia and five others in whom choreo-athetosis was also present. In Table II are summarized the pertinent data in the family histories. For statistical purposes, the patients have been divided into three groups: forty-seven with diplegia; twenty-five with hemiplegia, quadriplegia, triplegia, or monoplegia; thirteen with predomination of cerebellar dysfunction. The patients with striatal symptoms are included in their respective diplegia or cerebellar groups and are not considered separately, thus avoiding reduplication of data. For the group as a whole, the age of the mother at the birth of the affected child was 29.8 years, with a standard error of 0.7 years. This may be compared with 26.1 years which was the average age

TABLE II

A SUMMARY OF PERTINENT FEATURES IN THE FAMILY HISTORIES

	TOTAL	DIPLEGIA	HEMIPLEGIA, ETC.	CEREBELLAR
Number	86	47	25	13
Maternal age (yr.)	29.8 ± 0.7*	28.6 ± 1.1	31.8 ± 1.7	30.2 ± 2.0
Proportion of first born *observed*	35% ± 5	38%	53%	23%
Proportion of first born *expected*	33%	32%	50%	38%
Proportion of later born (four or later) *observed*	31% ± 5	38%	31%	30%
Proportion of later born (four or later) *expected*	23%	32%	14%	22%
Mean birth rank *observed*	3.1 ± 0.2	3.5	2.4	2.9
Mean birth rank *expected*	2.6	3.0	2.0	2.3
Families with more than one affected child	6.5%	3%	0	33%
Incidence of mental deficiency in nonaffected siblings	6.2% ± 1.5	5%	5%	11%

*Standard error.

of the mothers at the birth of almost two million children in the United States census area in 1934.[2] The difference of 3.7 years is over five times the standard error of the difference and is highly significant. The average for the different groups have similar significance. Murphy[7] carried out a similar study in a large group of children with congenital malformations of various types. He found that the average maternal age at the birth of the defective child was 28.4 years as compared to 26.4 years at the birth of the normal children in the same families.

There is no significant difference between the percentage of affected children who were first born and the percentage expected on the basis of chance selection. This is also true for the individual groups and is particularly interesting in the case of patients with diplegia because of the frequent unsupported statements in the literature to the contrary and the use of these statements as evidence tending to implicate birth trauma as the etiologic factor, since the incidence of difficult labor is admittedly greater in the primipara. There is, however, suggestive evidence that a greater proportion of the patients with cerebral palsy are born after the third pregnancy than should be expected on the basis of chance selection. This is equally true for each of the individual groups. This agrees with the observation that the mean birth rank of the affected patient is significantly higher than would be found by chance alone (3.1 ± 0.2 as compared with 2.6). A similar increase in the births of congenitally malformed children during the latter birth ranks was noted by Murphy.

In the total group, there were sixty-one families that had two or more children. Of these, four families had two children each similarly affected with cerebral palsy. These include one pair of siblings with diplegia, one pair with uncomplicated cerebellar ataxia, and two pairs with the cerebello-striatal syndrome. Thus, 6.5 per cent of the families having more than one child showed a recurrence of cerebral palsy in another later born sibling. Although the exact incidence of cerebral palsy in the general population is not known, it can be estimated that probably less than 0.01 per cent of the families would have a child so affected.[4] There is thus evidence of a possible genetic factor in some cases of cerebral palsy. Penrose,[8] in a study of sixty-six cases of diplegia, found seven patients who had similarly affected siblings and also suggested a possible genetic factor. Moreover, in six of his families, the parents of a diplegic patient were consanguineous. In our series, only in one family was parental consanguinity determined, although our data may not be complete enough in this respect.

In the families of our patients, there were 260 nonaffected siblings, sixteen of whom were mentally deficient. The diagnosis of mental deficiency was made by various state agencies and hospital clinics, and only those examined psychologically are included. Unfortunately, all the siblings were not examined. Presumably only those adjusting poorly in school or showing behavior abnormalities were referred by these

agencies for examination. It is therefore likely that the number of mentally retarded individuals actually found is a conservative estimate. However, accepting this figure at its face value, we obtain a ratio of 6.2 per cent mentally retarded. If we estimate the incidence of mental deficiency in the general population as from 1 to 2 per cent, there is a significant increase of mental deficiency in the nonaffected siblings of patients with cerebral palsy. This was also noted by Penrose[8] who raised the question of a possible common genetic factor.

The available details as to the birth histories are summarized in Table III. It will be noted that practically all the pregnancies were uneventful. About 85 per cent of the children were delivered at home, and of these about three-fifths were medically attended. A history of abnormal labor was obtained in about 25 per cent of all the cases. These included breech presentations, difficult forceps deliveries, prolonged labor associated with difficulty in resuscitation of the infant, etc. The greatest incidence of abnormal labor was found in the mothers of the infants with hemiplegia; almost 50 per cent of the deliveries were described as abnormally difficult.

TABLE III

A SUMMARY OF THE AVAILABLE DETAILS IN THE BIRTH HISTORIES

	TOTAL %	DIPLEGIA %	HEMIPLEGIA, ETC. %	CEREBELLAR %
Pregnancy uncomplicated	98	98	95	100
Delivered in hospital	15	15	12	23
Labor said to be abnormal	25	17	48	8
Incidence of prematurity	12% ± 3*	13	16	0

*Standard error.

The evaluation of data of this type is extremely unsatisfactory. Histories in most cases were obtained from ten to fifteen years after the birth of the child, and maternal impressions were in many instances obviously tinged by interim opinions and suggestions. It is reasonable to believe that the given data errs on the side of overestimating the incidence of abnormal labor. However, accepting the data as given, it must be assumed that, except for those with hemiplegia, in only a small proportion of the patients was the possibility of a birth trauma considered.

It will be noted that 12 per cent of the patients were born prematurely. The incidence of prematurity in the general population is given as 4 to 6 per cent.[5, 10] Since the mortality rate of premature infants during the neonatal period is estimated at about 20 to 30 per cent, the observed incidence of 12 per cent should be compared with an expected incidence of about 3 to 4 per cent. This difference is statistically significant and agrees with similar data from many other sources, including Little's original article. It is of interest to note that the incidence of premature birth among the congenitally malformed children

described by Murphy[7] was about 18 per cent as compared to 4 per cent in the children in his normal group.

Some of the pertinent clinical features in the various groups are summarized in Table IV. While the average age of the patients in the entire group is about 21 years, those in the cerebellar group are somewhat younger, averaging 14.4 years. The average mental level is represented by an intelligence quotient of 28. There was little difference in the levels of the individual group. It is apparent that our cases represent a narrow, selected group of patients with cerebral palsy, those with marked mental retardation as well as extensive motor handicap. This is to be expected since all patients required institutionalization. It is of interest to point out, however, that only about 25 per cent of the persons with cerebral palsy in the community are mentally defective or borderline.[6] Because of the marked degree of the cerebral defect in our patients, it is likely that any trends pointing toward possible causations would be accentuated in our group. However, until similar studies can be made in cases of congenital cerebral palsy that are more representative, including the larger group of the mentally normal patients, our conclusions must be considered tentative and suggestive only for this selected group of patients with cerebral palsy.

TABLE IV

A SUMMARY OF VARIOUS CLINICAL FEATURES

	TOTAL	DIPLEGIA	HEMIPLEGIA, ETC.	CEREBELLAR
Age (yr.)	21.2 ± 1.3*	22.5	22.7	14.4
Mental level (I.Q.)	28 ± 1.5	24	36	28
Sex distribution (Males)	52%	50%	68%	30%
Head circumference (cm.)	50.9 ± 0.3	50.0	52.6	51.5
Incidence of convulsive disorders	43%	37%	68%	15%
Incidence of associated physical defects	20%	30%	5%	0

*Standard error.

The sexes were equally distributed in the total group as well as in the individual groups. The differences noted in the patients in the hemiplegic and cerebellar groups are not statistically significant because of the small numbers involved.

It has been well recognized that the head size of the patient with cerebral palsy is smaller than normal. Our data agree with this. However, it should be noted that the major cause for the general reduction in head size is the relatively large proportion of the patients with diplegia (30 per cent) whose heads are less than 48 cm. in circumference. In the case of the other groups, the distribution is not strikingly unusual, and the average is not much reduced from normal values. This is especially true in those in the hemiplegic group.

As might be expected because of the underlying cerebral lesions, there is a high incidence of convulsive disorders in the patients in the group

as a whole. Thirty-six of the patients had histories of recurrent convulsions. In the patients in the diplegic group, six cases started before the third month of life; nine cases, between the first and second year; and three cases, after the eighth year. Three of the patients with cases that started before the first year had convulsions for only from two to four months and have been free of convulsions since. All of the others continued to have convulsions of varying severity and frequency. Of the patients in the hemiplegic group, four cases started between the second and sixth month; five cases, between the second and seventh year; and three cases, between the tenth and fourteenth years. All of these patients have continued to have convulsions of varying degrees. Only two patients in the cerebellar group had histories of convulsions, both of these starting during the latter part of the first year, and both have continued with relatively mild spells. In general, the patients in the hemiplegic group showed the highest incidence of convulsive disorders (68 per cent), and these were generally more persistent and severer than those in either of the other groups.

One of the more interesting observations was the occurrence of a relatively high incidence of associated congenital defects and malformations in the patients in the diplegic group. These consisted primarily of eye defects, including four cases of bilateral cataracts; one, unilateral leucoma; one, diffuse bilateral corneal opacities; and five, strabismus. There were also found four patients with bilateral optic atrophy. In addition, one patient had a congenital absence of the septum pellucidum which was demonstrated by encephalography. One patient with a congenital heart abnormality and one with syndactylism were also found. In the hemiplegic group there was one patient with bilateral corneal opacity. It is apparent that the incidence of these abnormalities is much greater than can be explained on the basis of chance selection. The high incidence of eye defects, when considered in connection with the close embryologic relationship between the central nervous system and eye, adds further suggestive evidence in favor of malformation or maldevelopment as basic in the etiology of the majority of the patients with cerebral palsy.

DISCUSSION

There is no doubt that a proportion of the cerebral palsy conditions are etiologically related to cerebral lesions acquired as a result of birth trauma or due to pathologic processes effective antenatally. In our series, on the basis of the birth and neonatal histories and the immediately postnatal physical and laboratory findings, it was felt that birth injury had occurred in at least four patients. These include one patient with quadriplegia and three with hemiplegia. The possibility that brain trauma may have occurred in other patients cannot be entirely ruled out on the basis of the available information. Cerebral palsy may also result from antenatal infections involving the central nervous system, like toxoplasma encephalitis, or neonatal infections such as the

various virus encephalitides. While the diagnosis of these conditions may be made with reasonable certainty in typical cases, it is likely that occasional cases may go undiagnosed in patients when seen for the first time later in life. It is also clear that other adverse prenatal conditions as yet unrecognized may also result in cerebral lesions. The type of statistical analysis herein employed does not differentiate between these acquired defects and those of a developmental or genetic nature. However, it can be stated that our data do indicate certain general trends in our patients with cerebral palsy that would be difficult to reconcile with the concept that the acquired lesions, such as those resulting from birth trauma, or the other conditions mentioned above were the major causative factors.

The moderately increased average maternal age in the absence of evidence that the first born is more likely to be affected has interesting implications. Similar observations have been made in such conditions as mongolism[2] and achondroplasia.[3] Murphy,[7] as previously mentioned, has also shown this to be true in his series of patients with congenital malformations. At present, the significance of this observation in terms of pathogenesis is not entirely clear. Benda, Dayton, and Pronty,[1] in their study of mothers of mongolians, have suggested a "threshold condition of sterility" in the older mother which increases the possibility of pregnancy taking place under less than ideal conditions and thus resulting in the greater likelihood of an "unfinished child." It is apparent that further clarification of these observations are necessary. The observation that the average birth rank in the cerebral palsy cases is somewhat later than normally expected, and that the incidence of later born is greater, are probably related to the fact of greater maternal age at time of birth.

The possibility that there may be a genetic factor of recessive or multiple nature involved in the problem of certain of the patients with cerebral palsy is suggested by the observation of multiple cases in the same family. This is particularly true in the patients with the cerebellar syndrome, where in one-third of the families having more than one child, a similar clinical syndrome was demonstrated in another sibling. Penrose[8] described a similar situation in his study of patients with spastic diplegia and also suggested the possibility of an underlying genetic background. Murphy[7] also found a tendency for the appearance of similar malformations in later born siblings in his study on congenital defects, but suggested the possibility of some maternal factor which might be responsible for "reproductive inefficiency." The observation that the incidence of mental retardation is significantly greater in the nonaffected siblings of the patients with cerebral palsy, an observation which agrees with the findings of Penrose, might also imply a genetic relationship. However, further discussion along this line is hardly warranted until more information can be obtained from other studies of a similar nature, especially those involving genetic interrelationships.

The presence in our series of an unusually high incidence of physical defects other than those of the central nervous system is of interest in also pointing to the possibility of developmental malformations as of importance in the causation of cerebral palsy. Particularly suggestive is the unusual number of defects involving the ocular system.

SUMMARY AND CONCLUSIONS

A clinical study of eighty-six patients with cerebral palsy is presented. The following observations were made:

1. The average age of the mother at the time of birth of the affected child is significantly greater than that found in the general population.

2. The affected children tend to have a later ordinal birth rank than would be normally expected.

3. There is a significant incidence of similarly affected siblings of patients with cerebral palsy.

4. The incidence of mental deficiency in the nonaffected siblings is greater than would be expected from random selection.

5. There is an unusually high incidence of associated physical defects, especially those involving the eyes, in the patients with cerebral palsy.

It was suggested that these and associated observations can best be reconciled with the conception of the primary importance, in the causation of cerebral palsy, of developmental cerebral malformations, of which a proportion may be genetically determined.

In support of this contention there were pointed out certain similarities in the results of this study with other studies on cases of congenital defects and malformations.

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THE CLINICAL MODIFICATION OF WHOOPING COUGH BY THE USE OF ALUM-PRECIPITATED DIPHTHERIA TOXOID

Experimental and Clinical Studies

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FIRST INVESTIGATIONS

A CASUAL observation of the improvement in the duration, number of attacks, and intensity of whooping cough in a family whose children were being immunized against diphtheria suggested this study.

A total number of fifty-four patients treated for whooping cough with the alum-precipitated toxoid prepared by the Mexican Health Department gave a high percentage of improvement with favorable modification in whooping cough. We do not claim a cure for the disease but only a diminution in the number of spasmodic attacks and in their intensity. In the actual duration there is little modification, although, as will be seen later, it is somewhat shorter than is common in Mexico. In these patients there were no fatalities or complications.

Becoming interested in this study, we searched for the causes which could sustain the possibility that the diphtheria toxoid could be useful when employed to modify an already existent case of whooping cough.

Kendrick (1941),[1] in a comparative study of the use of alum-precipitated whooping cough vaccine and alum-precipitated whooping cough vaccine in combination with diphtheria toxoid for active immunization, obtained results which refer to our own point of view (Table I).

It can be observed that in the patients vaccinated with the combined vaccine there is a greater immunologic response than in those vaccinated with the standard vaccine.

On the other hand, it is known that diphtheria is one of the diseases which produces the formation of antitoxin with great rapidity when an individual has been attacked by the disease. "In certain individuals," says Shick,[2] "the cells of some individual are able to prepare antitoxin so quickly that the toxin of diphtheria bacillus can be neutralized at a time when its amount is still very small, in fact so small that not even symptoms of diphtheria can be detected."

In other individuals, the formation of diphtheric antitoxin in the organism is somewhat more slow, and this gives rise to the development of serious diphtheria and the greater or less conservation of immunity. Outside of these individuals unable to form antitoxin rapidly, it can be affirmed that diphtheria toxoid is one of the few

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TABLE I

ALUM-PRECIPITATED TOXOID DIPHTHERIC COMBINED WITH PERTUSSIS VACCINE: INTERMEDIATE TABULATION OF THE FREQUENCY OF WHOOPING COUGH IN THE PATIENTS INJECTED AND IN THOSE IN CONTROL GROUPS

	TOTAL GROUPS	VACCINATED GROUP		CONTROL GROUP
		COMBINED	STANDARD	
Number of children	2,194	847	380	967
Years—person	1,536	610	386	540
Attacks	69	4	6	59
Attacks per 100 years—person	4.5	0.7	1.6	10.9

antigens which is capable of calling the immunity response of the defensive elements so rapidly as to reach a grade where no symptoms are produced in individuals free of the infection and without previous active immunity.

This fact added to the statistics of Kendrick of the greater immunity obtained in children to whom the combination of pertussis vaccine and diphtheria toxoid was applied, together with the improvement observed in the intensity and number of attacks of the patients with whooping cough whom we studied, as well as the results of the experiments which we obtained in laboratory animals, have made us think of the possibility that an antigen of the diphtheria toxoid type is capable of activating the immunity defenses of an individual attacked by an organism such as the *Bacillus pertussis* which requires by itself a longer period to obtain a defensive response.

Experimental Procedure.—Lapin[3] published a test in rabbits protected with pertussis vaccine to judge the antigenic effect of the vaccine as well as the protection of the same laboratory animals by convalescent serum. In our study we made use of similar tests according to the following procedure, modified partly in conformity with our own ideas, to obtain a greater immunity by combining the pertussis vaccine with the alum-precipitated diphtheria toxoid.

Three groups of rabbits were selected for immunization and another lot was left as control.

1. *In the first lot* we injected subcutaneously every other day a progressively increasing dose of pertussis vaccine prepared according to the technique of Kendrick, at the Institute of Biology of the Health Department of Mexico,[4] which contains 10,000 million organisms per cubic centimeter. The total dose of vaccine injected in the rabbits in this lot was 20 c.c.; this corresponds to a total of 200,000 million. To reach the total dose, two weeks were employed.

After the last injection, we allowed two weeks to elapse before making the intradermal test, injecting by this route 0.2 c.c. of a live culture of *B. pertussis*. Each cubic centimeter of this suspension of live *B. pertussis* had a concentration of 5,000 million per cubic centimeter.*

*It is known that in the unprotected rabbit, after injection with a live culture of *B. pertussis*, a scar with necrosis forms at the site of injection after three or four days.

2. *In the second lot* we injected subcutaneously at intervals of four days one-half the dose of *B. pertussis* given the rabbits in the previous lot; that is, a total which corresponds to 100,000 million organisms and three injections of alum-precipitated diphtheria toxoid. Two weeks

Fig. 1.—Test rabbit.

Fig. 2.—Rabbit injected with pertussis vaccine alone.

also were allowed to pass before making the same intradermal injection of 0.2 c.c. of the live culture of *B. pertussis* used in the previous lot.

3. ***In the third lot*** we injected only alum-precipitated diphtheria toxoid at the intervals of four days, a total of 3 c.c. subcutaneously. After

Fig. 3.—Rabbit injected with alum-precipitated diphtheria toxoid only.

Fig. 4.—Rabbit injected with pertussis vaccine and with alum-precipitated diphtheria toxoid.

two weeks the rabbits were also injected intracutaneously with the same suspension of live *B. pertussis.*

The control lot was injected with the suspension of virulent bacillus to obtain the formation of necrosis or scar. We made this injection to determine whether we were using a culture of *B. pertussis* with the required virulence so that our experiment would be of value (Table II).

TABLE II

RESULT OF THE EXPERIMENTAL STUDY

CONTROL LOT	NECROSIS AND SCAR
First lot—protected with pertussis vaccine alone	
Rabbit 677	Small scar
Rabbit 438	Small scar and edema
Rabbit 319	Small scar and edema
Second lot—protected with pertussis vaccine and alum-precipitated diphtheria toxoid (the dose of pertussis vaccine was one-half of that injected in the preceding lot)	
Rabbit 235	Circumscribed edema and small ecchymosis
Rabbit 320	Edema and very small ecchymosis
Rabbit 322	Edema and medium ecchymosis
Rabbit 19	No edema or ecchymosis
Third lot—injected with alum-precipitated diphtheria toxoid alone	
Rabbit 431	Large scar and necrosis
Rabbit 7	Extensive edemas and ecchymosis

Interpretation of Experimental Studies.—

First Lot: The rabbits injected with the dose of 200,000 million pertussis vaccine alone were protected when compared to the test lot; for although there was the formation of a scar at the site of the intracutaneous injection of live bacillus, there was no development of the extensive necrosis which was observed in the test animals.

Second Lot: The rabbits injected with the 100,000 million pertussis vaccine (one-half the dose of the previous lot) combined with 3 c.c. of alum-precipitated diphtheria toxoid were the best protected, for no scar or necrosis developed and in Rabbit 19 there was absolutely no lesion.

Third Lot: The rabbits injected with alum-precipitated diphtheria toxoid alone were not protected, for lesions developed similar to those of the test lot.

From our experience we make the following conclusions:

1. That protection is obtained in the rabbits with the pertussis vaccine prepared according to the technique of Kendrick.

2. That better protection is obtained by combining this vaccine with diphtheria toxoid.

3. That the diphtheria toxoid alone does not protect the rabbit against the live *B. pertussis.*

CLINICAL STUDIES

Method.—Thus far fifty-four cases of clinically indubitable whooping cough have been carefully studied. Cultures were made in some of them, but no case was included in the study in which the cough in the patient was not spasmodic, with vomiting, congestion of the face during the attack, and final noisy inspiration, with a minimum duration of a week of the spasmodic cough, so that the clinical diagnosis of whooping cough may be considered as certain.

For a better interpretation, the date at which time the cough became spasmodic was noted, so that it must be considered that the whooping cough had begun approximately a week before that date.

The term "improved" expresses the condition of the patients in whom the number of attacks and their intensity diminished to such an extent that the diminution of the number of attacks and their intensity was clearly perceptible to the results of the test. To better check the fact of diminution in the number of attacks, the parents of the patients were told to make notes, by means of lines and dates, of the number of times that the children coughed. The last group of patients was the one in which it is considered that the treatment failed, considering the fact that in Mexico City whooping cough frequently lasts from four to five weeks with spasmodic cough and occasionally even longer.

The ages of the children studied were between 4½ months and 9 years. No influence due to age was noted.

In children less than 6 months old we injected ½ c.c. of the alum-precipitated toxoid at weekly intervals and with a minimum of three doses.

To children from 6 months to 2 years we gave 1 c.c. with the same interval and dose.

To those older than 2 years we gave 1½ c.c. per dose from the first injection.

In no case were observed manifestations of intolerance or annoyance in the children.

Results.—

Number of patients studied thus far	54
Patients in the first group improved on the second week from the beginning of spasmodic cough	37
Patients in the second group improved on the third week from the beginning of spasmodic cough	11
Patients in the third group improved on the fourth week or more after the beginning of spasmodic cough	6

We have observed nine cases of contacts which were injected with alum-precipitated diphtheria toxoid before they had begun to cough,

and which were seemingly protected for there was hardly any cough. These patients require further study.

CONCLUSIONS

Experimental Study.—

1. The rabbit is better protected with a mixture of pertussis vaccine and alum-precipitated diphtheria toxoid than with pertussis vaccine alone against the intradermal injection of live *B. pertussis.*

2. It is also protected with the pertussis vaccine alone prepared according to the technique of Kendrick.

3. Diphtheria toxoid alone does not protect the rabbit.

Clinical Study.—Of fifty-four children with whooping cough, thirty-seven improved two weeks after the beginning of the spasmodic cough and eleven after three weeks. The method failed in six instances.

SUMMARY

In this experimental and clinical study of whooping cough we have observed the utility of the diphtheria toxoid precipitated in alum combined with pertussis vaccine. It has protected rabbits against necrotic lesions when they are injected intracutaneously with live *B. pertussis.* Rabbits to which a combination of pertussis vaccine and diphtheria toxoid precipitated in alum was given were better protected than rabbits to which pertussis vaccine alone was given and rabbits injected with diphtheria toxoid.

As a result of the clinical study of fifty-four children with whooping cough injected with diphtheria toxoid precipitated in alum, thirty-seven improved within two weeks after the beginning of the spasmodic cough and eleven after three weeks, while in six children no improvement was noted.

NOTE.—If these studies are carried out and confirmed by others, it may be expected that the employment of diphtheria toxoid will be applied in other diseases where it is necessary to increase the immunity response of the organism.

This work was done principally at the Institute of Tropical Diseases of the Mexican Department of Public Health. We wish to acknowledge our thanks to its Director, Dr. Miguel Bustamante, and to Miss Leonor Ramirez Vazquez (Chemist).

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TREATMENT OF EPIDEMIC DIARRHEAS AND DYSENTERIES IN INFANTS AND YOUNG CHILDREN

Comparative Study of Different Treatments and Their Results

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DIARRHEAS and dysenteries in newborn infants, infants, and young children are not only the cause of long ailment and hospitalization, but also of many deaths every year. Table I*A*, I*B*, and I*C* show the importance of the condition from the public health aspect. The majority of cases are treated by practicing physicians and in clinics, and only the more severe cases are referred to hospitals.

We wish to discuss certain changes in our treatment which have decreased the morbidity and mortality and considerably simplified the management of the case in homes with untrained nursing staff. Tables II*A* and II*B* show the improvement of the results during the last years.

We have divided our patients into two groups, those with diarrheas and those with dysenteries. In the first group we placed all patients with cases classified as nutritional diarrhea and those whose cases were caused by parenteral infection. The second group contains all patients with "specific" diarrhea caused by organisms belonging to the dysentery group.

Except for the isolation technique observed in the dysentery form and the different selection of sulfonamides, we have applied the same method of treatment in both conditions.

TREATMENT

With the irritative state of the intestines, rest has to be provided. A period of starvation of twelve hours has been found satisfactory and has been practiced on all patients. During this time, the patients did not receive any food. Water and medication were given as needed.

Dehydration is the most dreaded complication of diarrhea. Greatest attention was given to the prevention and treatment of this condition. The oral and intravenous ways were used practically exclusively. Our patients received plain, sterile water from the time of admission. By cup or bottle, water was offered at fifteen- to thirty-minute intervals, and the child encouraged to drink even if resistance was offered. In

From the Pediatric Department of the Louisville General Hospital.

TABLE IA

TOTAL DYSENTERY CASES (ALL FORMS) REPORTED* IN THE STATE OF KENTUCKY IN JULY, AUGUST, AND SEPTEMBER, 1938 TO 1942

YEAR	JULY	AUGUST	SEPTEMBER	TOTAL FOR YEAR
1938	107	69	41	396
1939	114	82	46	348
1940	9	55	23	242
1941	241	80	45	470
1942	20	24	12	108

*Cases reported to Division of Communicable Diseases, Kentucky State Department of Health.

TABLE IB

DEATHS FROM DIARRHEA AND DYSENTERY IN THE STATE OF KENTUCKY IN JULY, AUGUST, AND SEPTEMBER, 1940, 1941, AND 1942*

YEAR	DIARRHEA			DYSENTERY		
	JULY	AUGUST	SEPTEMBER	JULY	AUGUST	SEPTEMBER
1940	44	91	114	14	31	16
1941	164	161	148	58	43	50
1942	121	83	88	31	30	23

*1942 is preliminary only.

TABLE IC

DEATHS FROM DIARRHEA AND DYSENTERY IN KENTUCKY AND THE UNITED STATES, 1937 to 1942*

YEAR	KENTUCKY		UNITED STATES	
	DIARRHEA	DYSENTERY	DIARRHEA	DYSENTERY
1938	1196	207	18,508	2,933
1939	792	205	15,128	2,537
1940	578	112	13,537	2,460
1941	827	251	Data not available	
1942	496	133	Data not available	

*1942 is preliminary only.

TABLE IIA

YEAR	TOTAL NUMBER OF PATIENTS	DEATHS	DEATH RATE (%)	HOSPITALIZATION AT TIME OF DEATH (DAYS)	LONGEST HOSPITALIZATION TIME OF DECEASED PATIENT (DAYS)
1938	96	36	37.5	12.1	64.0
1939	51	9	17.6	12.1	23.0
1940	57	16	28.0	10.0	30.0
1941	65	10	15.1	0.69	3.0
1942	58	6	10.34	0.66	1.33

TABLE IIB

CORRECTED STATISTICS WITH ELIMINATION OF ALL PATIENTS WHO DIED THIRTY-TWO HOURS OR SOONER AFTER ADMISSION

YEAR	TOTAL NUMBER OF PATIENTS	DEATHS	DEATH RATE (%)	HOSPITALIZATION AT TIME OF DEATH (DAYS)	LONGEST HOSPITALIZATION AT TIME OF DEATH (DAYS)
1940	57	11	19.3	15.0	30
1941	65	2	3.07	2.5	5
1942	58	0	0	0	0

TABLE IIIA

THE USE OF SULFONAMIDES IN OUR SERIES

DISEASE	MEDICATION	NUMBER OF CASES	AVERAGE DAYS OF HOSPITALIZATION
Flexner's dysentery	Sulfathiazole	3	15
	Sulfaguanidine	4	15
	No sulfonamide	0	--
Total		9*	
Sonne dysentery	Sulfathiazole	3	7
	Sulfaguanidine	2	10
	No sulfonamide	0	--
Total		5	
Negative laboratory report	Sulfathiazole	12	16.6
	Sulfaguanidine	3	9.0
	No sulfonamide	9	6.5
Total		24	
No laboratory report found on records	Sulfathiazole	9†	8.55
	Sulfaguanidine	1	5.0
	No sulfonamide	4‡	14.75
Total		19	
Morgani dysentery		1	
Grand total		58	

*One patient died before treatment could be started (twenty hours); one patient left the hospital in less than twenty-four hours against advice.

†Two patients died before treatment could be started effectively.

‡Three patients died before treatment could be started effectively.

TABLE IIIB

THE USE OF SULFONAMIDES IN OUR SERIES

Sulfathiazole Given to Thirty-Two Patients	
Stool reports:	
Negative for dysentery	12
Positive on admission	
Flexner	5
Sonne	3
Morgani	1
No report found on record	11*
Total	32
Sulfaguanidine Given to Ten Patients	
Stool reports:	
Negative for dysentery	3
Positive on admission	
Flexner	4
Sonne	2
No report found on record	1
Total	10†
No Sulfonamide Given to Sixteen Patients	
Stool reports:	
Negative for dysentery	9
No reports found on record	7‡
Total	16

*Three patients died before stool specimen could be obtained. The case of one patient was reported "positive" on discharge; he left the hospital against advice.

†All cases were reported "negative" on discharge.

‡Three cases died before stool specimen could be obtained.

cases of advanced dehydration or acidosis, in addition to the oral route, intravenous fluid was given. By continuous drip through a fixed ankle vein cannula, a steady flow of physiologic salt solution, 5 per cent glucose in sterile water, or one of the two Hartman's (Hartmann's) solutions, was given for the first thirty-six hours.

After hydration has improved, we have found that blood transfusions are of greatest value to increase the resistance of the child and improve his general condition. In some cases where hemoconcentration was too high, plasma has been given.

Sulfathiazole and sulfaguanidine have been used extensively in our series of patients. We have tried to treat the nonspecific type of diarrhea with sulfathiazole and the specific diarrhea with sulfaguanidine. Due to delayed diagnosis, however, we have treated some specific types with sulfathiazole. Tables III*A* and III*B* show our results with these drugs.

Bismuth and paregoric have been used only in extreme treatment-resistant cases. In one patient, polyvalent dysentery antiserum has been used with striking result.

The system of feeding and its administration has been changed radically in our institution during the past years. It also differs from the routine used in other hospitals and by most practicing physicians. We believe that our method saves valuable time for the physician as well as for the nursing staff of hospitals and certainly simplifies the care at private homes by untrained personnel.

It is customary to offer and give only very small amounts of milk per feeding, measured exactly and with careful supervision, and to increase this amount very slowly and under very strict regulation. We have abandoned this method entirely and, as shown in the tables, have had better results than in previous years.

Beginning twelve hours after admission to the ward, we have offered full bottles to our infants and given them as much as they will take. We have neither limited the amount nor forced the intake. The orders read: "Buttermilk as tolerated," or "Skimmed boiled milk ad libitum." Tables IV*A* and IV*B* show the very large amount of intake in the two age groups selected. The conclusions from these tables are as follows:

1. That the children have taken very large amounts of milk per feeding.

2. That they have regulated their intake according to their appetite without harm to the progress of their recovery.

3. That where too large amounts were offered, the child has limited the intake according to appetite.

4. That the improvement made rapid progress, and recovery occurred before the average hospitalization time of the patients treated by other methods two or more years ago.

Following are some of the advantages of this form of diet:

1. The caloric value of the forms of milk to which diarrhea patients have to be limited is far below the value of whole milk or ordinary milk formulas. Buttermilk, skimmed boiled milk, and protein milk average from 10 to 12 calories per ounce. Breast milk and customary milk formulas rate about 20 calories per ounce.

The caloric demand of a weakened undernourished child is certainly higher than the one of a healthy child. We believe, therefore, that the time of complete recovery can be shortened considerably.

Table V shows the decrease of hospitalization time during the past years. It has to be remarked that other factors besides the patient's medical condition influence the discharge time considerably. The social background, the use of a convalescent home, the overcrowding of our hospital, and the cooperation of a social service department are of decided importance.

The question arises: Why not order a certain amount per feeding according to caloric requirements? Our charts have shown, since we are dealing with sick children and low caloric food, that the calculated amounts will be very high, and that the nurse will be inclined to force the ordered amount. Especially in private homes, the mother will always be very concerned whether or not the baby has taken the "whole formula." The forcing of intake would, however, be not only of no value, but also very farmful to most patients.

2. The treatment of the hospital patient is greatly simplified by this method. The order written on the first day holds good for as many days as the physician wants to continue the same form of milk, irrespective of the amount.

Comparing our orders to the attendant with those specifying the exact amount of milk, with the indications for time of changes daily or half daily, we can readily see the advantage of simplicity and clearness.

3. A still greater advantage of this liberal method of feeding is the treatment of the patient with diarrhea in private practice at the home of the patient with untrained and often not understanding nursing care. It is very difficult to instruct mothers coming from the less educated part of the population to measure feedings exactly. It is certainly next to impossible, to enforce limitation of feedings when the child continues to cry and the mother feels that the cause is hunger. This has been a considerable burden to the doctor, and many unpleasant disputes originated from the "starving" of the patient.

During the statistical test period in 1942, the following milk forms have been used: Buttermilk, skimmed boiled milk, and protein milk. In this we are using different methods from those used in previous years when whole boiled milk with or without sugar added and evaporated milk formulas were used. All those preparations contain a higher amount of dextrose and have a slight laxative effect (Table VI).

TABLE IVA

TEN OF OUR PATIENTS IN THE AGE GROUP OF THE FIRST ONE-HALF YEAR OF LIFE

INITIALS	AGE IN MONTHS	FEEDING (C.C.)																	
		FIRST DAY*						SECOND DAY						THIRD DAY					
		1ST	2ND	3RD	4TH	5TH	6TH	1ST	2ND	3RD	4TH	5TH	6TH	1ST	2ND	3RD	4TH	5TH	6TH
Eight Patients for Whom the Order Read "As Tolerated" or "Ad Libitum"; Buttermilk or Skimmed Boiled Milk Was Given; During the First Twelve Hours the Patients Received Only "Sterile Water"																			
D. C.	4	120	120	120	60	60	180	180	180	180	180	150	130	150	150	150	180	180	180
M. D.	4	90	90	150	120	120	120	120	120	180	150	60	120	120	120	120	60	60	120
M. E. G.	5	120	120	120	120	120	120	240	240	120	240	240	--	240	240	200	200	200	--
D. A.	1	120	120	75	120	120	--	120	120	90	105	90	120	120	120	120	120	120	--
M. A. A.	4	200	100	100	50	100	100	--	100	100	100	--	--	200	200	200	100	200	--
D. P.	6	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180
J. R. M.	2	--	--	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120
J. M. R.	5	120	120	120	--	120	120	150	150	150	150	150	150	150	150	150	150	150	150
Two Patients for Whom the Order Was Specified (180 c.c. and 90 c.c. Respectively)†																			
J. H.	6	120	60	165	150	180	150	180	180	60	180	180	180	180	180	90	180	180	180
D. M.	1	--	--	60	60	60	60	60	60	60	60	60	60	90	90	90	90	90	90

*Note the large amount of intake beginning the first day.

†Note the intake regulation by the child according to his appetite.

TABLE IVB

TEN OF OUR PATIENTS IN THE AGE GROUP OF THE SECOND ONE-HALF YEAR OF LIFE

INITIALS	AGE IN MONTHS	FEEDING (C.C.)																	
		FIRST DAY*						SECOND DAY						THIRD DAY					
		1ST	2ND	3RD	4TH	5TH	6TH	1ST	2ND	3RD	4TH	5TH	6TH	1ST	2ND	3RD	4TH	5TH	6TH
Eight Patients for Whom the Order Read "As Tolerated" or "Ad Libitum"; Buttermilk or Skimmed Boiled Milk Was Given; During the First Twelve Hours the Patients Received Only "Sterile Water"																			
D. V.	11	--	--	200	200	--	--	30	200	150	250	--	--	200	200	200	240	--	--
J. S.	8	--	--	35	60	30	--	90	90	90	90	90	--	90	90	120	120	120	--
P. G.	7	--	--	240	240	240	--	240	240	240	180	240	--	240	240	240	240	240	240
E. E. C.	10	90	90	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180
J. L. M.	8	--	--	120	105	120	--	120	120	170	180	120	180	120	190	190	190	190	120
W. D.	11	--	--	240	240	240	240	240	240	240	240	240	240	240	240	200	200	200	240
M. F. W.	6	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120
A. T.†	8	90	90	120	180	120	80	120	120	120	150	150	180	120	120	150	150	150	150
Two Patients for Whom the Order Was Specified (180 c.c. and 90 c.c. Respectively)‡																			
C. T.	7	180	180	180	180	180	180	120	120	180	180	180	180	180	180	180	180	180	180
B. J. D.	9	--	--	45	60	60	60	60	60	90	30	90	30	60	60	90	60	60	90

*Note the large amount of intake beginning the first day.

†Patient A. T. took on the second and third days two additional feedings each (150 and 120 c.c., 150 and 180 c.c.)

‡Note the intake regulation by the child according to his appetite.

TABLE V

AVERAGE NUMBER OF DAYS OF HOSPITALIZATION OF PATIENTS WHO LEFT THE HOSPITAL IN "IMPROVED" OR "WELL" CONDITION

YEAR	DIARRHEAS	DYSENTERIES
1938	15.0	14.6
1939	20.5	18.6
1940	15.6	15.7
1941	9.0	6.8
1942	11.4	11.3

TABLE VI

FORMS OF MILK GIVEN TO OUR PATIENTS IN THE MONTHS OF JULY, AUGUST, AND SEPTEMBER, 1942

NUMBER OF PATIENTS	FORM OF MILK
41	Buttermilk
7	Skimmed boiled milk
1	Protein milk
1	Whole boiled milk
6	Evaporated milk formulas
4	Nothing (Died before feeding time)

The above table is made to show the forms of milk which were ordered on admission. Only patients whose history showed that buttermilk was not well tolerated received skimmed boiled milk or protein milk.

Evaporated milk formula or whole boiled milk was given only to those patients who were admitted primarily for another condition or under another diagnosis.

In some cases the formula was changed during the course of the hospitalization if we felt that the child was not responding to the treatment the way he should.

Upon cessation of the diarrhea, which we considered established after the number, consistency, color, and odor of the stools had returned to normal for from two to four days, a gradual change was made to a normal formula. We accomplished this by replacing fractions of the average amount of buttermilk taken and by increasing those fractions in from twenty-four- to forty-eight-hour intervals until the normal formula was reached.

SUMMARY AND CONCLUSION

1. Diarrheas and dysenteries have been classified in this paper in two groups: the non-specific and the specific forms.

2. Considered are the patients treated in the Louisville General Hospital during the months of July, August, and September from 1938 to 1942, with special attention to the patients of 1942.

3. A new method of feeding has been put on trial and was found successful during the last two years, as proved by the following facts:

(a) The average hospitalization time has decreased (TableV).

(b) The total number of deaths has decreased (Table II).

(c) The death rate has decreased (Table II).

(d) The average and individual hospitalization time of the patients who died in the test months in 1942 was so short as to justify these patients being considered moribund on admission as done in Table II B, showing a death rate of zero included in our statistics.

4. The new method consists in the administration of unlimited amount of feedings, selected especially for the diarrhea case.

5. The main principles of our treatment are outlined below:

(a) Starvation period (twelve hours).

(b) Oral and intravenous hydration and combat of acidosis.

(c) Feeding of buttermilk, skimmed boiled milk, or protein milk in from three to four hourly intervals, the amount regulated entirely by the appetite of the patient.

(d) Sulfathiazole and sulfaguanidine.

(e) Plasma and blood transfusions.

(f) Specific antiserum therapy.

(g) Bismuth and paregoric only in treatment of the resistant patient.

PROBLEMS IN MANAGEMENT OF RHEUMATIC DISEASE IN CHILDHOOD

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PAST INTEREST IN MANAGEMENT OF RHEUMATIC DISEASE

IN THE past two decades many contributions have been made to the knowledge of the epidemiology and natural history of rheumatic disease in childhood. The bulk of observations deals with statistical analysis of morbidity and mortality figures and a classification of the type and degree of cardiac damage. The comprehensive work of Wilson,[1] the analysis of Cohn and Lingg,[2] and the studies of Paul[3] bring the chapter on natural history of rheumatic disease to a most satisfactory stage.

Many attempts have been made to find the etiologic agent. Bacteriologic and immunologic studies as yet lack confirmation. The cause of rheumatic disease is thus far unknown. It is the opinion of clinicians that the disease is probably an infection. There is, however, no clear-cut indisputable evidence for this contention.

The study of the causes of this baffling disease has occupied the attention of most students in this field, while the patient as an individual and his many problems arising directly from the crippling effects of his disease has played a minor role in our medical thinking. The treatment of rheumatic disease in childhood has received only minor attention. The management of a disease process which presents so many bizarre manifestations is beyond the ability of the family physician. A morbid condition with many disputed angles is discouraging to the public health administrator. A disease whose acute phase is often measured in terms of months or years is a distinct annoyance to hospital authorities. A disease whose downward progress is measured in decades cannot possibly fire the imagination of the public. Finally, the crippling irreversible effects of the disease have discouraged the most ardent workers in the field of public health.

Thus the interest in the management of rheumatic disease in childhood has been in the matter of classification and disposition of cases. That the rheumatic child is to become a cardiac "cripple" has been an accepted conclusion. The crucial question has been how to modify the environment to apply to the rheumatic cardiac child. The task in the foreground of the management of this disease has been to prepare the child for the handicap to come. The most thoughtful and thorough scheme[4] for a communal approach to the management of rheumatic disease stresses the disposition of cases as they come in review.

From the St. Francis Sanatorium for Cardiac Children, Roslyn, L. I., and Childrens Cardiac Clinic at The Kings County Hospital.

Some admirable attempts have been made to prevent rheumatic recurrences by institutional treatment or chemotherapy. Because of the many unsolved problems in the full understanding of the behavior of the disease, these attempts have been unsatisfactory, discouraging, and costly. In some instances[5] the results were most promising, but these constituted only a very small fragment of the total problem.

Few attempts have been made to view the management of rheumatic disease in childhood from the point of view of the individual patient. The bizarre character of the disease, its insidious nature and unpredictable course, and its chronicity punctuated by storms of acute episodes present sociologic, psychosomatic, and educational problems which may produce lasting and irrevocable dents in the life pattern of the individual patient.

Whether the disease is an allergic state, an inherited predisposition, or an infection does not materially influence the problem of management of the disease as it already exists. Conservatively estimated, there are probably 500,000 children in the United States suffering from this disease. Looking at this problem in a realistic manner, those already afflicted must be taken care of. Prevention of recurrences is only one part of the problem. Prevention of the initial attack must be postponed until the etiology of the disease is known. Prevention of the downward progress of this illness in the individual patient is the most pressing public health problem. Finally, the treatment of heart disease in the advanced stage is no less a public health concern than the treatment of the initial stages; many children with hopeless cases have been restored to useful life; those with hopeless cases who do not bring any returns to the community also deserve our best care from a purely human standpoint.

CLASSIFICATION OF CASES FROM POINT OF VIEW OF MANAGEMENT

A. From the Clinical Standpoint (Fig. 1)

Acute Phase.—Looking at the disease from the point of view of management, various types of classifications come to mind. The clinician classifies his cases of rheumatic heart disease into five groups.

The child who suffers from an acute arthritis, an acute chorea, or an acute carditis with heart failure is treated in a manner not unlike any patient who is affected with any other acute illness. He is thus placed in a hospital where the personnel and equipment for the treatment of acute illness are at hand. And since rheumatic disease attacks children in the lower income groups, these children are treated on the wards of municipal and private hospitals. Furthermore, it is assumed that the patient is to remain in the hospital until the acute phase has subsided, and, since specific diagnostic tests are lacking, the decision as to the time of discharge rests with the physician in charge of the particular ward.

In our experience, this setup is inadequate from the point of view of the individual patient. The beginning of the acute phase precedes admission to the hospital by weeks; its duration is much longer than is apparent from clinical observation. Most acute episodes begin with mild symptoms and signs (in the majority of cases unrecognized) and roll up slowly and insidiously until the obvious explosion occurs. It is at the explosive stage that the patient is hospitalized. The explosion subsides in a few weeks, but in all patients a slow subclinical active disease continues for months after the explosion. Although the preexplosive and postexplosive stages are not easily recognized, it is agreed by most students of rheumatic disease that treatment at these stages is of paramount importance if cardiac damage is to be prevented. Under the present setup, therefore, the patient is admitted

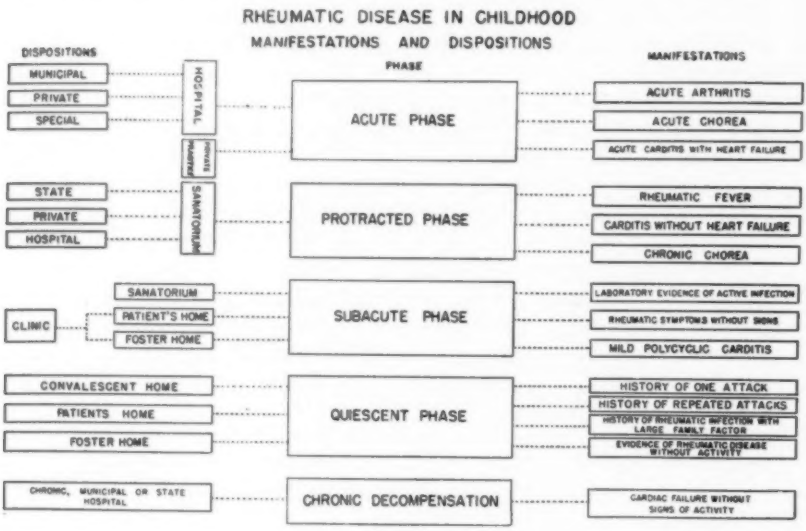

Fig. 1.

too late and discharged too early. On the other hand, if the period of treatment be extended to cover the entire active period of the disease, rheumatic children would soon displace all other pediatric cases. In addition, it is a common observation that the active phase of rheumatic disease seems to flourish in a hospital environment.

Protracted Phase.—When several weeks have passed and the patient still has signs of active disease, he is classified as a "protracted" case. These children are discharged home to remain in bed and report to a clinic from time to time. In some instances the child is sent to a convalescent home. In this group of cases are found children with rheumatic fever, carditis without heart failure, and chronic chorea. It is obvious that this phase of the disease does not differ in any important

respect from the acute phase except in the matter of degree of activity. Thus the continuity of treatment is broken in a continuous disease process.

From the point of view of total management of this disease, this phase of rheumatic disease is of even greater importance. The signs and symptoms and laboratory tests are evasive. It requires considerable judgment and close observation over a period of many months to determine when the acute phase is definitely at an end. The degree of cardiac damage is proportional to the degree of medical neglect during this phase.

Subacute Phase.—After the patient remains in bed at home for several weeks, he returns to the clinic for reclassification. The child may not present any obvious signs of carditis or chorea but continues to show some laboratory evidence of active rheumatic disease. During this phase the child complains of mild rheumatic symptoms. Rapid examination and judgment formulated under extreme pressure in the overcrowded clinic fails to detect mild rheumatic activity. The child is returned to the community and assumes normal childhood activity while harboring a mild rheumatic inflammatory process in the heart muscle. This is the child who returns two years later with unequivocal signs of mitral stenosis and enlarged heart and from five to ten years later has marked depletion of cardiac reserve and at or immediately past adolescence becomes a cardiac invalid.

Quiescent Phase.—Much has been said about the quiescent phase of rheumatic disease in childhood. When the quiescent phase begins or ends is unknown. The diagnosis of quiescence is based upon a lack of evidence of activity. A patient who presents a history of rheumatic fever and at the time of examination does not present physical or laboratory evidence of active infection is said to be in the quiescent phase. An interruption of the quiescent period by obvious signs of rheumatic infection is said to be a recurrence. A close observation of a quiescent group of children shows that there is no clear-cut distinction between quiescence and activity. Repeated careful examinations and laboratory studies show that quiescence is punctuated by short periods of mild activity. The base line of quiescence is characterized by small undulations. Those undulations which rise above the clinical horizon are called recurrences. The importance of the subclinical undulations in the natural history of the disease has not been clearly evaluated. It is reasonable to assume on the basis of long follow-up studies that many cases continue to develop progressive cardiac damage as a result of these mild rheumatic episodes. How much cardiac damage could be prevented by a better understanding and closer observation and treatment of the rheumatic patient during the "quiescent" phase?

Chronic Decompensation.—The last and most discouraging group in this classification is the chronic decompensator. An attitude of hope-

lessness dominates the management and treatment of this group of children. Some public health students feel that the expense of energy and money on the treatment of this group of children is an economic loss. These hearts are beyond repair and therefore cannot possibly be restored to communal usefulness. Students in human physiology are too ready to discard this group of children into the heap of cripples—the cardiac reserve can no longer be restored to sustain life and normal activity. Thus the care given to these children is done out of a sense of humility rather than hopefulness and restoration. In our experience, there is cogent evidence to show that chronic decompensation in childhood is another expression of protracted rheumatic activity. We are encouraged by the fact that a large proportion of these "hopeless cripples" may yet be restored to usefulness and their life cycle prolonged if they are not discarded too easily in our plan of management of rheumatic disease.

It is clear, therefore, that the classification of cases on the basis of clinical manifestations is unsatisfactory. The various phases of the disease are not clear-cut and probably do not bear any definite relationship to progressive cardiac damage. Frequent observation and extensive investigation bear fruit among the so-called quiescent group as well as among the active group of children.

B. From the Therapeutic Standpoint

A close study of 2,200 cases at the Kings County Hospital shows that rheumatic children fall into several distinct classes from the point of view of therapy. In general, one might say that some belong in the category of incurables; some need the active treatment offered at a hospital for acute conditions, some do very poorly at a hospital; others do exceptionally well in sanatoria; still others do poorly under an institutional regime and do better at home; still others will not do well either in an institution or in their own environment but will improve to a great extent in a foster home; and there are few who need only to be followed up from time to time in a clinic and do well even in their poor home environment. Most of the cases will do well when discovered early in the course of the disease and placed in a proper environment.

On the basis of our experience with rheumatic children in the hospital, in the clinic, at their homes, and in the sanatorium, one is impressed with the fact that every child must be treated as an individual case. However, while the classification of rheumatic cases from the clinical standpoint is difficult, from a practical standpoint and particularly from the standpoint of the management of the case, it is possible to classify these cases into four main categories:

1. Children who should be treated either at their own homes or foster homes.

2. Children who should be treated on the hospital wards.

3. Those who should have a short stay at the hospital and then be transferred to a good environment for prolonged convalescent care.

4. Those who must be treated in a sanatorium.

1. *Home Cases.*—About one-half of our cases who are patients at the Children's Cardiac Clinic are so-called quiescent rheumatic patients. Some of these children present themselves with a definite history of an acute rheumatic episode but do not demonstrate any signs of active rheumatic infection and have minimal cardiac damage. The children in this group, however, do not do well from other points of view. They are pale. They fail to gain weight properly. They have repeated upper respiratory infections. They do not, as a rule, take part in the average childhood activities because they are not as robust as their playmates.

A large number of these children show more cardiac damage at the end of several years of observation. It is conceivable, therefore, that during the period of observation mild rheumatic episodes were missed. We observed that when the children of this group are removed from their home environment or when the home environment is readjusted, the physical well-being of the children is markedly improved. The amount of cardiac damage found in the children of the latter group at the end of several years of observation is definitely smaller than in those in the group who remain in the original home environment. It is tempting to assume that mild rheumatic episodes are prevented by an improvement in the child's environment.

Another large group are those children who have rheumatic endocarditis and had one or two episodes of active rheumatic disease. Since the last active episode they suffer from mild symptoms of rheumatic infection but do not demonstrate any laboratory evidence to substantiate the diagnosis of active infection. In this group of children proper nutrition seems to be the dominant factor in preventing active episodes.

A moderately large number of children visit the clinic during the quiescent period but have frequent active rheumatic episodes, most of of them short in duration and apparently unattended by carditis. In this group of children nutrition alone does not play an important role in the prevention of recurrences. It seems that the home environment plays a leading role in the causation of rheumatic reactivation.

A small group of children come to the clinic because of the discovery of cardiac murmurs. Only about one-fifth of the children in this group are found to have organic heart disease. Most of these do well in their own home environment. Only a small proportion of these children develop rheumatic recurrences.

2. *Hospital Cases.*—About 10 per cent of the children in our cases can be treated most efficiently with the aid of facilities offered by a hospital for acute conditions. In this group oxygen, intravenous in-

fusions, blood transfusions, and various forms of cardiac emergency measures constitute the daily regime. These are the children who, either as a result of one acute rheumatic attack or a series of attacks over a number of years, have sustained sufficient cardiac damage to cause heart failure. The greatest majority of the children in this group have acute pancarditis with decompensation. Some show only laboratory evidence of active rheumatic infection but are definitely decompensated. A few of our children in this group have heart failure without evidence of active rheumatic infection.

The mortality in this group of children is extremely high. In our group, it was found to be as high as 70 per cent. The treatment is not clear-cut. The failing hearts with active rheumatic carditis probably should be treated differently than those without active carditis. The use of the well-established cardiac drugs does not always produce the expected pharmacologic results. Much remains to be learned about the treatment of this group of children.

3. *Short Hospital Stay Followed by Long Period of Convalescent Care.*—About 15 per cent of the children in our cases have acute rheumatic episodes of short duration. A number of children in this group are admitted to the hospital with a definite history of rheumatic fever. The dominant manifestations are fever, joint pains, nose bleeds, advancing pallor, loss of weight, and fatigue. On admission children with such a condition demonstrate the arthritic phase of rheumatic fever and also present evidence of carditis. Under salicylate therapy the arthritic symptoms subside and in a period of from two to six weeks after the arthritis has subsided, all evidence—both clinical and laboratory—of active infection has gone. The child may then be declared to be in a quiescent stage. When such a child is returned from the hospital to a poor home environment, not more than an average of six months elapses before that child returns to the hospital with a rheumatic recurrence. However, if such a child is sent directly from the hospital to a sanatorium, rheumatic recurrences seem to be prevented or at least postponed.

Some children are admitted with an acute rheumatic arthritis without any other evidence of active rheumatic carditis. All evidence of active rheumatic infection subsides within from two to three weeks. In many of these children, however, the sedimentation rate remains elevated. It has been observed that, when these children are returned home with an elevated sedimentation rate, the majority return to a hospital in an active phase of rheumatic disease within four months. It has also been observed that when these children are kept in the hospital beyond the period of activity, they are at least twice as susceptible to rheumatic recurrences on the hospital wards as in their own homes or in another environment.

Finally, in this group also belong those children who are admitted with acute chorea. It has now been well shown among our cases that

the greatest majority of these children do well under some form of heat therapy. One-fourth of the children in these cases, however, do not do well after the active chorea has subsided. They fail to gain weight, their anemia advances, they often complain of other mild rheumatic symptoms, such as joint pains, muscle pains, epistaxis, and fatigue, although from the laboratory standpoint they are found to be "inactive." These children, when returned to a poor home environment, invariably develop either a recurrence of chorea or new manifestations of active rheumatic disease.

It is therefore clear that this group of children do poorly in the hospital if they remain on the wards for a long period of time after the acute episode. Those who suffer a mild carditis after the acute infection do best in a sanatorial environment. The children in the group who do not show evidence of active rheumatic carditis after the acute episode will continue to do well at a foster home or at their own home where the environment is suitable. The children who recover from an attack of acute chorea do poorly at home; a long stay at a convalescent home seems to postpone or prevent other attacks.

4. *Sanatorial Group.*—About 25 per cent of our children should be treated in a sanatorium. These children have active rheumatic disease of long duration. Some continue to be moderately active from the inception of the disease to death from acute carditis. The period of activity in the children in this group in our experience ranged from one month to over four years. During this period and particularly in those children in whom the period is measured in terms of years, the degree of activity fluctuates from mild activity determined only by laboratory methods to severe active carditis with decompensation. But at no time does all evidence of activity subside. The children in this group develop more and more cardiac damage under observation. It is obvious that children with such a condition must be constantly under medical supervision. It is also clear that since they frequently go into acute phases of carditis, most modern methods of hospital care must be available for them. The duration of the illness precludes private or municipal hospital care. Furthermore, the serious nature of this phase of the disease excludes care at home or in a foster home. The sanatorium, therefore, seems to be the place of choice for this group.

A large number of the children in this group are admitted to the hospital with a diagnosis of rheumatic carditis not preceded by the usual arthritis or chorea or other manifestations of rheumatic fever. The children in this group present a difficult problem in diagnosis. The majority of them do not show, on the first admission, severe cardiac damage and may have only minimal cardiac enlargement. Many of these will show only laboratory evidence of active rheumatic infection in addition to a rapid heart rate. Most of these children run this mildly active course for weeks and months. Usually at the end of a long period of mild activity the heart is found to be definitely more

damaged than at the beginning of the episode. It has been observed in our group of children that this type does very poorly on the hospital wards. More definitely it has been shown that the duration of the active episode is at least one-third longer in the hospital than under another environment. In addition, it has been shown that the reactivation of the rheumatic process is more frequent and of greater severity at the hospital than in another environment. There is convincing evidence to show that these children should be treated in a sanatorium.

Finally, there is a small group of children who have a mild chorea of many months' or years' duration with slowly progressive cardiac damage. The children in this group can be treated properly only in a sanatorium. There is evidence to show that certain psychologic factors are responsible for prolongation of this phase. The environment at home or on the hospital wards is definitely harmful to these children. Furthermore, heat therapy is of little avail. A sanatorium where proper regard is given to the psychosomatic factors, as well as the cardiac status, is the place of choice for these children.

It seems clear from such a classification of cases that before therapy can be properly directed, one must use considerable judgment in each individual case. While the diagnosis is not always clear, sufficient definite and clear-cut criteria present themselves to make such a classification feasible and workable. It must be remembered, of course, that an individual child may fall into several or all classifications at various times in its rheumatic career. In many children, therefore, frequent reclassification becomes necessary in order to attain the best therapeutic results.

Our observations show clearly that hospital care is a deterrent rather than a help to the child with rheumatic disease in the majority of instances. We are impressed with the fact that certain phases of this disease must be treated in a sanatorium particularly adapted for rheumatic disease. Other phases of the disease can be treated at the home of the patient or in a foster home. Still other phases can be managed best in an acute hospital, but only for a short period, to be followed immediately by a long period of convalescent or sanatorial care.

C. On the Basis of Natural History of the Disease

The critical analysis of Cohn and Lingg[2] shows that fully two-thirds of rheumatic heart disease is found in childhood and that the prognosis will depend roughly upon the age of onset and the severity of the initial attack. Thus the younger the child is at the age of onset, the more guarded must be the prognosis from the point of view of rheumatic reactivation, degree of cardiac damage, and duration of life cycle. Furthermore, the prognosis depends also upon the type of initial onset. "When the infection is 'severe' in the early years of the disease, expectancy is shorter than if the infection is mild."

It would seem therefore that the factors which influence the course of the disease are the age of onset, the type and severity of infection, and the number of reactivations. It is also clear that the three factors go hand in hand. "When the disease begins in childhood, carditis is the most frequent but rarely the only type of infection." "The earlier the age at onset, the greater the chance that infection will be severe during the next few years." "They are most prevalent before puberty rather than the first five years after onset."

Four hundred rheumatic children were closely observed under treatment over a period of six years. All observations were made by me. The purpose of these observations was to evaluate the age factors with regard to the onset of the disease, the severity of the initial and recurrent attacks, the duration of the active period of the disease, and the extent of cardiac damage at the end of the period of observation. This group of children consisted of 100 children whose condition was diagnosed as rheumatic carditis at the initial attack; 100 children who had rheumatic symptoms and laboratory evidence of active rheumatic disease but did not demonstrate any evidence of carditis; 100 children who had arthritis as the first attack; and 100 children who had chorea as the initial attack.

The severity of rheumatic infection is judged by the duration of the active period and the extent of cardiac damage. In accordance with these criteria, rheumatic carditis is considered the most severe form of rheumatic active infection. Our experience also teaches that rheumatic fever as an initial attack in the age group under observation (that is, children from 5 to 15 years of age) is a severer form of active rheumatic infection than rheumatic arthritis. Judged by the same criteria, it is common experience that chorea is the mildest form of rheumatic infection.

Our studies emphasize the following observations:

1. The younger the child at the age of onset, the more severe the initial attack (Table I).

2. The more severe the initial attack, the more frequent the recurrences (Table II).

3. The more severe the initial attack, the longer the duration of active infection (Table III).

4. The younger the child at the age of onset, the more protracted the active rheumatic episodes (Table IV).

5. The more severe the onset and the younger the child, the greater the cardiac damage at the end of a period of six years (Table V).

These observations bear a realistic relationship to the management of the disease. If the primary aim in treatment is prevention of cardiac damage and prolongation of life expectancy, it would seem obvious that the management of rheumatic disease would have to be planned upon the basis of age of onset and severity of infection at the time of onset.

TABLE I

MANIFESTATIONS OF RHEUMATIC ACTIVITY AT DIFFERENT AGE GROUPS—FIRST ATTACK

AGE GROUP (YR.)	NUMBER OF CASES			
	CARDITIS	ARTHRITIS	RHEUMATIC FEVER	CHOREA
5 to 8	48	18	22	8
9 to 12	32	38	36	63
13 to 16	20	44	52	29
Total	100	100	100	100

TABLE II

INCIDENCE OF RECURRENCES OF RHEUMATIC ACTIVE INFECTION FOLLOWING VARIOUS TYPES OF INITIAL ATTACKS

TIME ELAPSED SINCE INITIAL ATTACK (YR.)	CARDITIS 100 CASES (%)	ARTHRITIS 100 CASES (%)	RHEUMATIC FEVER 100 CASES (%)	CHOREA 100 CASES (%)
2	30	6	3	1
4	42	36	20	32
6	79	70	54	42

TABLE III

AVERAGE DURATION OF ACTIVE PERIOD—INITIAL ATTACK PER CHILD

AGE GROUP (YR.)	CARDITIS (DAYS)	ARTHRITIS (DAYS)	RHEUMATIC FEVER (DAYS)	CHOREA (DAYS)
5 to 8	164	30	124	32
9 to 12	110	66	104	73
13 to 16	96	68	108	53
Average for group	124	55	112	53

TABLE IV

TOTAL PERIOD OF ACTIVITY DURING PAST FIVE YEARS PER CHILD

AGE GROUP (YR.)	CARDITIS (MO.)	ARTHRITIS (MO.)	RHEUMATIC FEVER (MO.)	CHOREA (MO.)
5 to 8	29	6	22	8
9 to 12	18	14	26	15
13 to 16	17	20	27	18
Average for group	22	14	25	14

TABLE V

EXTENT OF CARDIAC DAMAGE AT THE END OF THE PERIOD OF OBSERVATION—SIX YEARS

	CARDITIS 100 CASES	RHEUMATIC FEVER 100 CASES	ARTHRITIS 100 CASES	CHOREA 100 CASES
*Cardiac enlargement				
Equivocal	7	11	18	52
Moderate	53	65	58	44
Marked	40	24	14	4
Functional classification				
Class I	42	58	81	91
Class II	25	21	6	6
Class III	9	11	7	1
Class IV	24	10	6	2
Mortality	24	10	6	2

*All cases were studied both by teleroentgenogram, right and left oblique plates, as well as by fluoroscopy. The average number of examinations per case over a period of six years was 32, or 6.3 examinations per year.

PROBLEMS IN MANAGEMENT

The management of any disease from the public health standpoint takes into account all phases of the disease. The fundamental philosophy behind total management of disease is continuity of care until such time as the patient does not need help of any kind. Modern concept of disease dictates care, not only during the acute phase of the illness, but also during the weeks or months that follow the acute phase when the patient is no longer within the hospital walls. Most patients need complete reorientation, physical, physiologic, and psychologic, after the acute illness. Thus total management of a disease demands a consideration of the medical, sociologic, and psychologic aspects of the disease.

The approach to the management of a disease may take various directions. Some students of public health will view the disease in a horizontal fashion. The disease is considered an invasion into the health fabric of the public. The management, therefore, is devoted to the treatment of the disease entity irrespective of the individual patient with his problems as an individual. Others believe that a vertical approach to the management of the disease eventually results in total control of the disease. The patient must be treated in all phases of the disease until he is restored to the community as a healthy member.

Some believe that for purposes of treatment an illness may be classified as acute or chronic. From the clinical standpoint this simple classification seems to include all known diseases and makes segregation of patients a practical matter. The distinction between acute and chronic disease is based in most instances on the duration of the illness. Thus, any illness whose acute phase lasts months is in most instances considered chronic. The admission of the concept of time into the classification of disease is a realistic approach to management. It has been customary to subdivide and keep distinct hospitals for acute conditions from hospitals for the chronically ill.

All students of public health and clinicians agree that the management of disease must result in benefit to the patient and his community. The aim is restoration of the individual to the group and thereby enhancing the health of the group. Isolation and segregation of the sick member of the community is temporary and is made for the purpose of bringing to the patient the best possible medical service.

The protean character of rheumatic disease, its bizarre and multiplicity of manifestations, its chronicity and crippling effects, its extent, and its mysterious nature demand a new approach to the management of disease. The line of demarcation between the acute and chronic phases is not clear. The danger of spread in the community has not been clearly evaluated. The full extent of the invasion into the health fabric of the public is not known but is definitely of greater

dimensions than most other illnesses. The lack of exact knowledge as to the etiology and natural history of this disease presents medical problems of considerable difficulty. The milieu in which this disease is commonly found brings to the foreground difficult sociologic problems. And since this is the greatest and most damaging of all childhood diseases, education presents a problem of great magnitude.

A. Medical Problems

Difficulty in Diagnosis.—The diagnosis of rheumatic disease is one of the hardest problems in medicine. When the diagnosis is obvious and the clinical picture meets the requirements of current medical teaching, the disease has usually already progressed to the dangerous stage. It is common knowledge that the initial phases of the disease escape the observation of many a keen clinician. Since the best results from treatment may be expected in the initial stages of the disease, the early diagnosis is our concern. The difficulty in early diagnosis presents a definite and most urgent problem in case finding.

Difficulty in Classification.—As has been shown elsewhere, rheumatic disease in childhood manifests itself in many and diverse ways. From the point of view of treatment a thorough knowledge of the type and nature of the manifestations is a primary prerequisite. In our experience, the classifications which are followed in most clinics and hospitals fall short of a true evaluation of the patient from the point of view of treatment. The classification, according to the extent of cardiac damage based upon subjective symptoms, is inaccurate in children. Objective measurements of cardiac function are still in the laboratory phase of development. Classification on the basis of clinical manifestation requires expert judgment. Such judgment can be gained only from a wide experience with cases.

Difficulty in Determining the Duration of Activity.—When the disease ceases to be active is at present impossible to state with accuracy. The usual clinical criteria, temperature, pulse rate, blood tests, cardiographic abnormalities, do not tell the entire story. It is obvious from most observations that the most important single criterion for continued treatment is the finding of active manifestations of the disease. It is also agreed that active rheumatic disease, however mild, must be treated with great concern and respect. It follows, therefore, that the diagnosis of rheumatic activity and the determination of the beginning or end of the active period require mature judgment.

Prognosis.—The prognosis as to rheumatic recurrences and the progress of cardiac damage can be made only after a thorough acquaintance with the progress of the disease in each individual patient. Statistical studies are helpful but not finally determinative in the individual case. In our experience recrudescence is not more common within five years of the initial attack. It rather seems to depend upon the type of initial

manifestation of activity and the age of the first attack. In addition, the occurrence of reactivations depends upon two other, not easily defined, factors—the general health of the patient during the so-called quiescent period and the environment in which he lives.

The prediction as to the extent of cardiac damage cannot wholly be made upon the number and type of recurrences. Large numbers of children continue to exhibit progressive cardiac damage without obvious signs of active rheumatic infection.

Treatment.—As long as specific therapy is lacking, the treatment of this disease is difficult, unsatisfactory, and costly. On the other hand, to await the discovery of specific therapy is hazardous from the public health standpoint. When the cause of rheumatic disease is known and specific immunologic treatment developed, there will still be an army of 1,000,000 people suffering from rheumatic cardiac damage. If prevention of the initial attack were possible, then the treatment of those already afflicted is our concern. If we succeed in preventing recurrences, case finding and distribution of preventive measures remain a public health problem of great magnitude.

From the medical standpoint, rheumatic disease has been compared to tuberculosis. In our judgment this comparison from the therapeutic standpoint is an unfortunate one. Tuberculosis, while a disease of long duration in many instances, in most cases and particularly in childhood is either completely arrested or leads in a small number of cases to a catastrophe. The disease is definitely a transitional one. The outcome is a matter of time, and there may be one of two results—complete restitution to the community or death. Thus, sanatorial care for tuberculosis is the ultimate goal to be attained, since in such a way complete medical care may be given until one or the other result is attained. Rheumatic disease, however, is unfortunately not as clear-cut in its management. The interval between the invasion and the result may be anywhere from weeks to dozens of years. The amount of damage caused by the invasion depends upon many ill-defined factors in addition to the duration and number of acute episodes. While some children do well in an acute hospital, sanatorium, or convalescent home, all children must be cared for from the beginning of the illness until at least past adolescence, whether the progress is precipitously downward or, in the main, slow and benign. One cannot be certain at any stage of the management whether the disease is finally arrested or quiescent. Complete restitution to the community can be attained only under continuous medical observation.

In a broader sense, the management of rheumatic disease deals with children suffering from a progressive disease of many years' duration. Untreated, this disease damages the heart beyond repair and, in addition, produces chronic invalidism with all the psychosomatic disturb-

ances that follow. Proper medical management, therefore, must aim at the following:

1. The arrest of active rheumatic progress.
2. Prevention of recurrent attacks.
3. Prevention of cardiac damage.
4. Prevention of psychic disturbances attendant upon chronic protracted illness.
5. Salvage of many of those who are considered hopeless cardiac patients.

It is obvious, therefore, that the medical management of the disease presents problems in diagnosis, prognosis, and treatment unlike those obtained in other diseases. The patient cannot reasonably ever be discharged from medical follow-up. This presents many sociologic considerations.

B. Sociologic Problem

A Disease of the Poor.—More than 90 per cent of rheumatic cases are found among children belonging to the poorer strata of the community. While the incidence of rheumatic disease in the upper economic bracket has not been thoroughly studied, it is a safe assumption that it is a disease of the poor. The cost of treatment and management must thus be part of the budget of the community.

Psychologic Problem.—In addition, the duration of the illness adds many problems in readjustment—a train of psychosomatic factors which must be dealt with in an intelligent manner. The psychologic damage may be of greater import than the damage done to the heart. The attitude of the child to the illness undergoes many changes. These mould the personality of the child so that when he recovers from his rheumatic illness, reorientation and adjustment become difficult, and he cannot therefore become part of his community. The normal and first attitude is resistance to the disease. The duration of bed rest and the ever-attentiveness of the surrounding milieu, doctors, nurses, parents, soon leads to a sickness libido. With the advance of cardiac damage comes an anxiety and revolt—an inimical attitude to parents and society born out of jealousy of normal siblings and playmates. The advent of adolescence with a recognition of physical handicap leads to resignation or migration to the unrealistic world of cultism. The attitude to society is nihilistic. Society has failed; it cannot be good.

Environmental Adjustment.—There is good evidence to show that poor environment at home is responsible, if not for the beginnings of the disease, surely for many recurrences of it. There are also cogent observations which unmistakably point to the fact that when the child is returned to a poor home environment after treatment, all gains are nullified. It seems that environmental factors play a definite role in

the natural history of this disease. Disturbances in the physical, biologic, and emotional environment seem to encourage the spread and progress of this disease.

C. Educational Problems

The extent of rheumatic disease in our childhood population is variously estimated to be from 1 to 2 per cent in the northern states of our country. It is conservatively stated that about 500,000 school children in the United States have rheumatic heart disease. As previously stated, it is a disease of long duration. Thousands of these children spend a good portion of their childhood years in bed. Their education is interrupted during the acute episode. Experience, however, shows that few rheumatic children of school age need be considered handicapped unless they have an active episode. Limitation of activity is unnecessary and possibly detrimental to a growing child whose cardiac reserve is normal. And in our experience a very small number, indeed, have impaired cardiac reserve during the so-called quiescent phase of the disease, irrespective of the presence of valvular damage.

Furthermore, the cardiac functional ability cannot easily be measured; the functional classification as determined by subjective symptoms in children is inadequate. The average child does not present subjective symptoms of cardiac insufficiency until he has reached the stage of imminent failure. In addition, it is well known that a child with normal cardiac reserve may go into failure with the advent of an active carditis. The change from Class I to Class III or IV may be dramatic and sudden or insidious and unnoticeable until failure supervenes.[6] The transition from one classification to the next in most children speaks for the beginning of a rheumatic active episode.

The stratification of children for the purpose of education according to functional cardiac ability, therefore, does not solve the problem. Segregation of children into cardiac classes is psychologically detrimental to the child. In addition, no child should be permitted to attend school with mild rheumatic activity, and most children with quiescent rheumatic infection may and should attend normal classes and take part in everyday childhood activities. The problem, therefore, for school authorities is the exclusion of rheumatic active children from school attendance and the inclusion into the normal fabric of education of all quiescent cases. The finding of the children with mild active disease is of far greater importance than the exclusion of a child with quiescent mitral stenosis from normal school activities.

Education, therefore, must play an important role in the management of this disease. Education of the rheumatic child during the period of active disease presents a problem in administration. The teaching must be continued at the hospital, sanatorium, convalescent home, or the home of the patient. Teaching during the period of

quiescence presents an even greater problem since these children must be ever watched for the advent of a mild active infection. Finally, the teaching of children with low cardiac reserve is a special problem in education.

The present setup for the education of rheumatic children is based upon the concept that the children may be treated in groups; those who have normal and those who have low cardiac reserve. As noted above, this classification is dangerous in this group of children. Any child with normal cardiac reserve may decompensate at the onset of an acute rheumatic episode. Furthermore, the greatest majority of children in the quiescent phase can partake in most childhood activities. The problem, therefore, is watchful observation for any signs or symptoms of activity during the course of the school years.

A more important phase of the education of these children is the purpose and aims. The possibility of the crippling of the heart must always be kept in the foreground of the plan of education. Some of these children are to be prepared psychologically to live with a handicap. It must be remembered that most of these children come from families where physical work is the order of the day and any departure from the accepted family tradition may be attended with a good deal of resistance. A rheumatic child must be guided through his early school years so that he may choose of his own free will the occupation or profession whose labor is well within his cardiac reserve.

In addition, it is the function of education to instruct the child about the manifestations of his disease and their importance, the value of frequent medical examination, the benefits or ill effects resulting from physical exercises, and the attitude to parents, siblings, playmates, and community.

CONCLUSIONS

It is clear then, that the problem of control and management of rheumatic infection in our childhood population includes all phases of childhood welfare. The medical, social welfare, and educational aspects are closely inter-related and constitute indispensable parts of a whole. The medical aspect deals with actual treatment and research. The social side of rheumatic disease deals with environmental readjustment and rehabilitation. Education of the child with rheumatic disease is an integral part of the program.

Since rheumatic disease is not a reportable disease, it lies in the main outside of the jurisdiction of hospital and health authorities. Thus, the care of these children at present is in the hands of private institutions, convalescent homes, municipal hospitals, child health agencies, etc., each one of which has its own methods, unrelated in most instances to the other agencies.

The total management of rheumatic fever and rheumatic heart disease thus presents a multiplicity of problems invading all aspects of

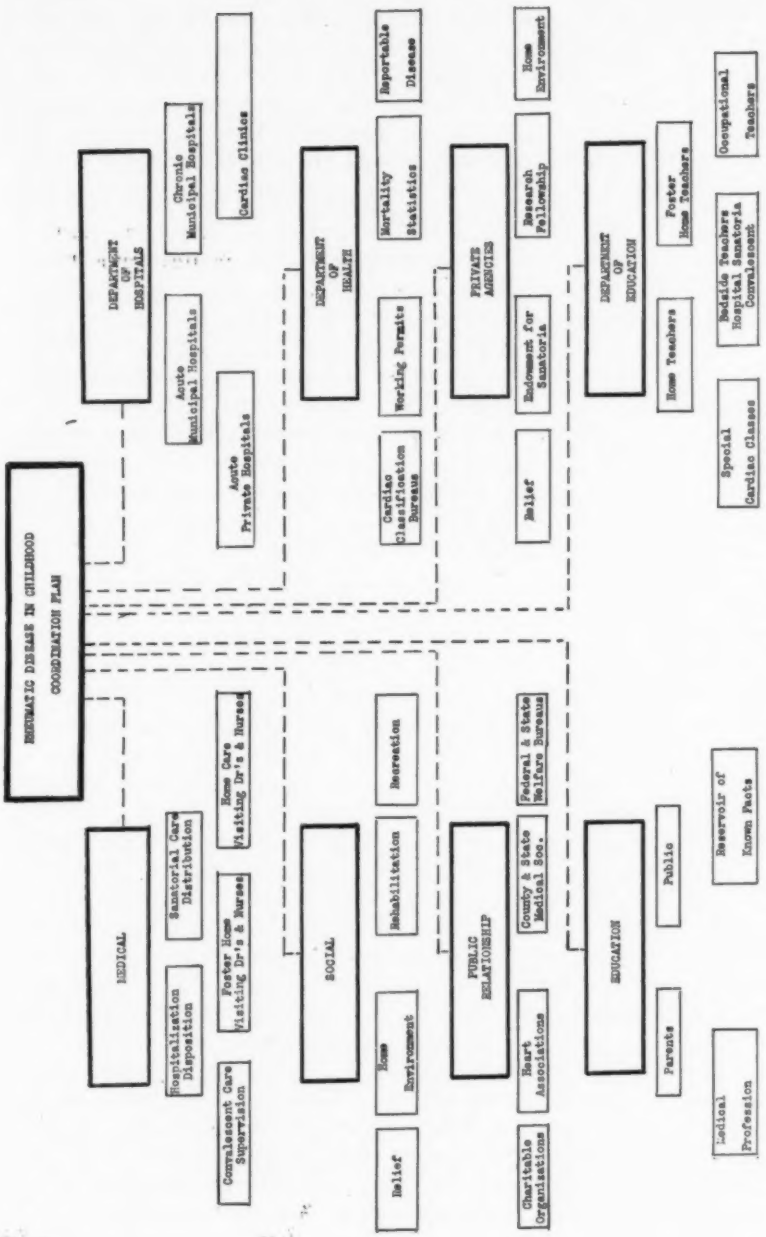
RHEUMATIC DISEASE IN CHILDHOOD
COORDINATION PLAN
MEDICAL
Hospitalization Disposition
Convalescent Care Supervision
Sanatorial Care Distribution
Foster Home Visiting Dr's & Nurses
Home Care Visiting Dr's & Nurses
SOCIAL
Relief
Home Environment
Rehabilitation
Recreation
PUBLIC RELATIONSHIP
Charitable Organizations
Heart Associations
County & State Medical Soc.
Federal & State Welfare Bureaus
EDUCATION
Parents
Public
Medical Profession
Reservoir of Known Facts
DEPARTMENT OF HOSPITALS
Acute Municipal Hospitals
Chronic Municipal Hospitals
Acute Private Hospitals
Cardiac Clinics
DEPARTMENT OF HEALTH
Cardiac Classification Bureaus
Working Permits
Mortality Statistics
Reportable Disease
PRIVATE AGENCIES
Relief
Endorsement for Sanatoria
Research Fellowship
Home Environment
DEPARTMENT OF EDUCATION
Home Teachers
Special Cardiac Classes
Foster Home Teachers
Bedside Teachers Hospital Sanatoria Convalescent
Occupational Teachers

Fig. 2.

human welfare. It demands an active mobilization of all possible public and private agencies concerned with the health and welfare of our childhood population. To make such mobilization effective, one must find a method of coordinating all these efforts (Fig. 2). Since such coordination does not exist in our present planning for health and welfare, a new approach is warranted. This departure from the accepted public health planning finds its origin in the fact that the disease entity that we are dealing with does not fit into any of the traditional schemes of treatment, management, and control.

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THE STATIC AND DYNAMIC PHYSICAL FITNESS OF ADOLESCENTS

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THE evaluation of the physical fitness of youths is a desirable procendure at any time, but in time of war the appraisal of adolescents, the subsequent correction of any defects found, and efforts to improve fitness in every way are vital. Adolescents who during recent years have been kept in schools because employment was not available are now in demand; much is going to be asked and expected of them, and it is proper that an increasing interest be shown in their fitness. Two aspects of physical fitness are considered in this report: static physical fitness, which is based on information found at the usual type of medical examination, and dynamic physical fitness, which has to do with the functional ability of the individual, his ability to do, and to recover from, strenuous exercise.

STATIC PHYSICAL FITNESS

Static physical fitness is more familiar but not less important; too frequently the apparent health of the adolescent leads one to believe that a careful examination will be fruitless, and when this attitude is taken, a cursory examination may be made. It is obvious that every effort should be made to find and to correct defects which interfere with the optimum function of an individual, and it is desirable that an individual should be made cognizant of any defect which may subsequently exclude him from any type of civil or military career. The value of the careful but rapid medical examination of boys in the 13- to 18-year age group can be indicated by a study of a summary of findings (Table I) made at the initial examination of 910 preparatory school boys.[1] These boys, because of the family income groups from which they come, may be more free of defects than those who have a less favorable economic status, and any percentages given here are probably lower than those which obtain for the general population. At least the data should serve to show that the careful medical examination of members of this group is a highly desirable procedure.

The findings listed in Table I require little comment. It is obviously in the correction of visual and dental defects that most can be done, but even the very occasional discovery of such conditions as early diabetes, rheumatic heart disease, an abdominal tumor, and undescended testes makes a careful examination a worth-while procedure. It is doubly valuable if every effort is subsequently made to have defects corrected.

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TABLE I

SUMMARY OF FINDINGS AT THE HEALTH EXAMINATION OF 910 BOYS RANGING IN AGE FROM 13 TO 19 YEARS

	NUMBER	PER CENT
Overweight	57	6.3
Underweight	54	5.9
Visual defects		
Color vision deficient	48	5.3
Vision, with glasses, one or both eyes:		
20/30	54	5.9
20/40 or less	37	4.1
Vision (no glasses) one or both eyes:		
20/30	11	1.2
20/40 or less	17	1.9
Hypermetropia (no glasses)	70	7.7
Heterophoria	43	4.7
Dental defects (based on 354 examinations)		
Caries:		
Need attention urgently	64	18.1
Need attention	290	82.0
Need orthodontia	44	12.4
Tonsillectomy advised	21	2.3
Adenoidectomy advised	3	0.3
Marked deviation of nasal septum	4	0.4
Chronic severe allergic rhinitis	8	0.9
Nose fracture with obstruction	1	0.1
Deformity of septum of ear	1	0.1
Dislocation of nose (anterior quadrilateral cartilage)	1	0.1
Perforation of ear drum	2	0.2
Auditory defects		
Loss of 20 decibels or more (high tones only)	23	2.5
Loss of 20 decibels or more (all tones)	15	1.7
Asthma	27	3.0
Hay fever	91	10.0
History of intimate contact with tuberculosis	21	2.3
Positive tuberculin test (0.01 mg. O.T.) 680 tested	177	26.0
Definite history of rheumatic fever	15	1.6
Rheumatic heart disease	6	0.7
Congenital heart disease	2	0.2
Dextrocardia	2	0.2
Hypertension		
Severe	1	0.1
Slight	2	0.2
Enlarged spleen		
Acute mononucleosis	1	0.1
Etiology unknown	3	0.3
Inguinal hernia	3	0.3
Duodenal ulcer	1	0.1
Fibroma of properitoneal tissues	1	0.1
Hydrocele	2	0.2
Varicosities of abdomen	1	0.1
Undescended testes		
One	4	0.4
Both	1	0.1
Posture defects		
Severe	10	1.1
Moderate	60	6.6
Slight	270	29.6
Recurrent shoulder dislocation	3	0.3
Lower back strain	4	0.4
Muscular atrophy (after injury)	3	0.3
Flail ankle and knee (poliomyelitis)	1	0.1
Cavus foot (poliomyelitis)	1	0.1
Pott's disease	1	0.1

TABLE I—CONT'D

	NUMBER	PER CENT
Impacted bullet (femur)	1	0.1
Cervical rib	1	0.1
Hammer toe	3	0.3
Unreduced elbow dislocation	1	0.1
Osteochondritis dissecans	2	0.2
Osteoma		
Femur	1	0.1
Tibia	1	0.1
Cyst of femur	3	0.3
Epidermophytosis (moderate or severe)	108	12.0
Eczema	4	0.4
Pityriasis	2	0.2
Fibroma of posterior skull	1	0.1
Impetigo	1	0.1
Acne		
Severe	65	7.1
Mild	164	18.0
Pigmented mole	2	0.2
Pilonidal sinus	20	2.2
Albuminuria		
Transient	45	4.9
Orthostatic	27	2.9
Diabetes	2	0.2
Endocrine disorder	5	0.5
Personality disorder		
Moderate	21	2.3
Slight	40	4.4
Speech defect		
Stuttering		
Severe	5	0.5
Moderate	10	1.1

DYNAMIC PHYSICAL FITNESS

The findings which we have just described are the result of a conventional medical examination, but such observations give no information in regard to the individual's fitness from a functional standpoint. They do not give the whole answer to the question, "What sort of condition am I in?" and yield no information in regard to his cardiovascular and respiratory response to exercise, his ability to do and to recover from brief, exhausting work. It seems reasonable to want to know and to investigate this dynamic or functional aspect of fitness just as it is reasonable to expect the prospective purchaser of an automobile to want to find out how well it behaves on a hill, how it operates under strain. A test of this type of fitness is of value for several reasons: (1) the amount of exercise proper for a given individual can be determined and his progress and benefit from that exercise can be evaluated; (2) the value of various exercise or physical training programs can be reliably determined; (3) groups may be divided into sections so that physical training programs suitable to each section can be employed: a much more efficient method than the indiscriminate assignment of all individuals to the same program regardless of their initial fitness; (4) individuals convalescent from illness can be more confidently advised to resume exercise and so that subsequently the effect

of that exercise can be determined. The relation of all these reasons for utilizing a test of dynamic fitness to aspects of the war situation is apparent. Physical education programs are being extensively developed, and if these conditioning exercises are not given under medical supervision and adjusted to the individual's state of fitness, damage may be done to the less fit, and the individuals in good condition may show little or no improvement. Without any means of testing fitness, a physician may tend to be too conservative in the care of convalescents and keep them from their jobs or exercise too long. This is a serious problem in the case of military and defense work personnel. It also raises the question of whether prolonged absence from exercise is the best method of returning a convalescent to good condition. It would seem more reasonable to measure his dynamic fitness and advise a gradual increase in exercise and then allow subsequent changes in his fitness to determine one's recommendations.

Any kind of exercise may be used in testing physical fitness providing (1) that the subject works at a constant rate for a given length of time, (2) that the exercise requires no special skill, and (3) that the exercise utilizes the large muscles and puts the cardiovascular and respiratory systems under strain. Strenuous but brief exercise will make very apparent marked differences in the fitness of individuals which would not be obvious if only moderate exercise were given. Dynamic physical fitness as we define it has nothing to do with the muscular strength or athletic skill of an individual. It is concerned only with his cardiovascular and respiratory response to exercise. Many tests of this type of fitness have been devised for adults. They are based on the principle that the rate at which a healthy individual's heart slows down after it has been accelerated by strenuous exercise can yield an index of his fitness. Extensive investigations have shown that reliable estimations of dynamic fitness can be obtained by utilizing only heart rates taken during the recovery period after exercise and that while additional information can be gained by studies of oxygen consumption and blood lactic acid levels, etc., these other data only supplement and corroborate the information which a study of the recovery heart rates yields.[2] The initial heart rate does not have a significant relationship to an individual's fitness, as it is easily modified by apprehension and should not be included in the calculation.[3] A similar comment can be made regarding blood pressure, and it might be well to emphasize at this point that the test we use differs from such tests as the Schneider in one essential particular: it is designed to estimate differences between *normal healthy* individuals; it is not designed to detect pathologic states. Occasionally a fitness test score based only on the ability of the subject's heart to perform and then to recover from work is criticized by the coach or trainer, who finds that one of his athletes has been given a low rating. This is only another indication that the individual's ap-

pearance and strength and skill are not indicative of his dynamic physical fitness at the moment and that they indicate only his potentiality in this regard. A simple example will make that clear. A crew man at the peak of his training period may have a fitness score of 130. The same man looking equally strong and healthy following a summer at farm work may have a score of only 80; months of absence from the sort of exercise which put his cardiovascular and respiratory systems under prolonged strain has shown itself by a striking drop in his fitness score and in a marked decrease in his heart's ability quickly to decelerate after strenuous exercises.

In an attempt to develop a test of dynamic physical fitness suitable for adolescents, large numbers of boys were exercised on a bicycle ergometer,[4] and during this work and during the subsequent rest period heart rate recordings were made on a Guillemin electrotachometer. Preliminary experiments made it clear to us that when dealing with subjects in this age group it is desirable to vary the friction load on the bicycle with the size of the individual, and we adopted the convention of adjusting that friction load on the basis of the subject's surface area. Fitness scores were calculated by using a slight modification of the formula proposed by Johnson, Brouha, and Darling:[2]

$$\text{Fitness index} = \frac{\text{Duration of exercise in seconds} \times 100}{\text{Sum of heart rates taken 1 to 1½, 2 to 2½, and 3 to 3½ minutes after exercise}}$$

The validity of using only three heart rate determinations has been amply shown.[5]

This index furnished us with a means of appraising the conditioning value of various sports and also of a special training program. It was, however, a relatively time-consuming method, and in an effort to devise a test which could be given quickly and without special equipment, we adapted a test which Brouha[4] has used for estimating the fitness of members of large groups of adults. This "step test," as we use it,[6] consists in stepping up and down from a platform at the rate of thirty times a minute for four minutes; the index is calculated on the basis of three heart rates taken during the recovery period. Large numbers of individuals can be tested in this manner at one time, depending only on the number of observers capable of taking pulse rates who are available. In order to adjust the test to the various sizes of boys in our age groups, it was found desirable to test all boys whose surface area was less than 1.85 square meters on an eighteen-inch step, and all larger boys, on a twenty-inch step.

In Fig. 1 is shown the distribution of fitness scores obtained by testing a group of 466 boys of various ages. These tests were given at the beginning of a school year. All these boys had surface areas of less than 1.85 square meters, and, therefore, the eighteen-inch step was used. The wide variation in scores among these boys, all of whom were in

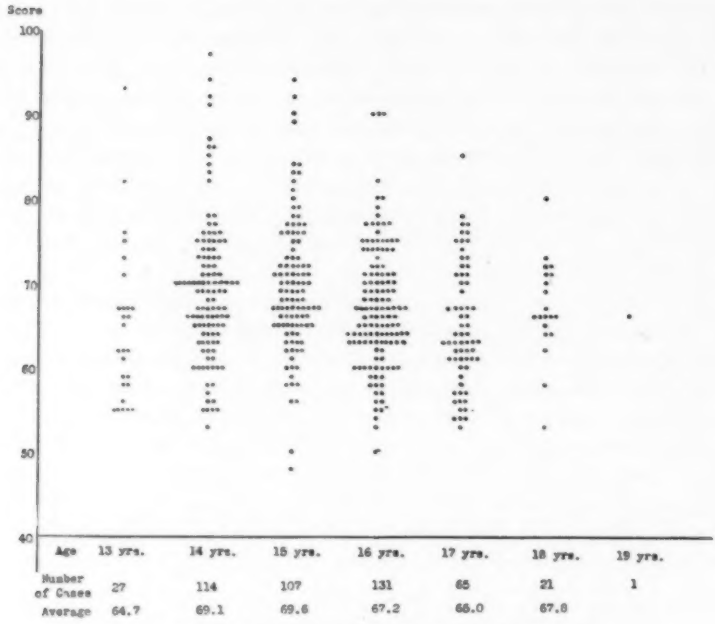

Fig. 1.—Score distribution by age groups (Group B).

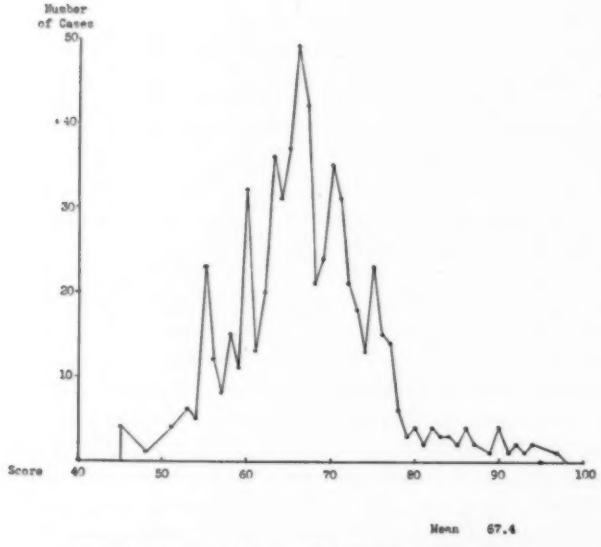

Fig. 2.—Step test score distribution (609 cases).

good health, is evident; the average scores for each of the age groups are approximately equal. In Fig. 2 a distribution of scores for 609 boys, 143 of whom were tested on the twenty-inch step, is shown, and the practicability of using such a test as this to divide large groups into about three sections, to each of which an appropriate training program might be given, suggests itself.

The brevity of this presentation of some remarks concerning dynamic fitness demands that an apology be made for several statements which have been included without supporting evidence. Detailed reports covering many aspects of this problem have been published recently. Our present purpose has been to urge that more attention be given to both the static and dynamic physical fitness of members of this age group. The test which we have described has been devised for the rapid testing of large groups. As with all such simplified methods, it cannot furnish a complete picture of all the factors which have to do with functional fitness, but it is reasonably accurate, and, if widely used, should prove to be a very useful tool and should help to develop a more widespread interest in functional physical fitness. The accusation that our citizens have become soft is not without foundation. Toughening is desirable, but it will be wise to correct this situation with the aid of tests to determine the efficiency of any conditioning or toughening program and with a previous estimation of the fitness status of the individuals one is attempting to benefit.

SUMMARY

1. Data obtained from initial medical examinations given a group of 910 preparatory school students are offered to support the opinion that careful medical examinations should be given members of this age group. The desirability of correcting as many defects as possible is emphasized, and the importance of making the individual cognizant of any defects which may affect his choice of career is indicated.

2. The value of determining an individual's functional or dynamic fitness in addition to making observations of him at rest is discussed, and the utilization of this information in evaluating and apportioning physical education programs and in managing convalescents is outlined.

3. Tests for evaluating physical fitness, based on the ability of the individual's cardiovascular and respiratory systems to perform and recover from brief, strenuous work, are described.

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THE EFFECT OF RACHITOGENIC DIETS, PARTIAL INANITION, AND SEX ON THE RESISTANCE OF COTTON RATS TO THE VIRUS OF POLIOMYELITIS

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TOOMEY (1937)[3] reported that the ingestion by *Macaca rhesus* monkeys of massive doses of vitamins A, B, and C did not protect these animals from the effects of the virus of poliomyelitis when the latter was injected intracerebrally or into the lumen or wall of the gut. On the other hand, when relatively large quantities of vitamin D were added to the diet, the monkeys were partially or wholly protected from the effects of the virus when the latter was injected into the lumen or wall of the gut, although they still became paralyzed when the virus was injected intracerebrally. Toomey deprived a number of monkeys of vitamin D for a period of four months, during which time they received several injections of vaccines made from the organisms of the colon groups and their toxins. Suspensions of the virus of poliomyelitis were then administered to these animals by injections beneath the serosa or directly into the lumen of a segment of the gut which had been isolated between clamps. All of the monkeys with vitamin D deficiency expired with anterior poliomyelitis within a period of twelve days, whereas the controls developed mild paralyses from which they soon recovered. Another group of monkeys was deprived of vitamin D for a period of two months, during which time they received from 150 to 200 c.c. of a 10 per cent suspension of the virus of poliomyelitis injected into the lumen of the gut. The monkeys with vitamin D deficiency all contracted the disease, whereas the controls which were fed vitamin D survived.

Schultz (1932)[2] and Toomey (1937)[4] reported that the virus of poliomyelitis is inactivated in vitro following a somewhat prolonged contact with ultraviolet irradiation. Toomey and Takacs (1938)[6] stated that Flexner's eluted mixed virus is inactivated in vitro upon prolonged contact with ergosterol and with drisdol (crystalline vitamin D in propylene glycol). However, inactivation of the virus of poliomyelitis was not demonstrable when crude suspensions of the virus were employed.

Toomey and Takacs (1940)[7] and Toomey (1941)[5] reported the results of interesting studies during the course of which suspensions of the virus of poliomyelitis were injected into the center of the adrenal

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glands of *Macaca rhesus* monkeys. Each of four monkeys fed adequate quantities of vitamin D and each of four other monkeys deficient in this vitamin were injected with 0.5 c.c. of purified virus into the center of the left adrenal. The four animals with vitamin D deficiency developed quadriplegia, but of the four controls, three remained negative and one developed a slight paresis (these authors were unsuccessful in reproducing the disease by injecting an emulsion of the spinal cord of this animal into the brain of another monkey). Toomey and Takacs reported further that when monkeys are made rachitic and their peripheral nerves are ground with the virus of poliomyelitis and the resulting mixture centrifuged, the virus is adsorbed or inactivated since the supernate is not infectious; on the other hand, when nerves from monkeys fed vitamin D are ground with the virus, the virus is not adsorbed since the supernate is infectious.

Toomey and his co-workers have expressed the opinion that the virus of poliomyelitis may propagate readily along nonmedullated nerve fibers, but that in attempting to progress along the course of a medullated nerve fiber, the virus may be adsorbed or repelled if the myelin is healthy. The ability of the myelin to adsorb or repel the virus of poliomyelitis, and hence to limit the spread of the infection, may be destroyed by a deficiency of vitamin D.

In contrast to the findings of Toomey and his collaborators, Sabin, Ward, Rapoport, and Guest (1941)[1] found no evidence, in a small number of monkeys, that the capacity of the virus of poliomyelitis to invade the central nervous system along peripheral nerves (the virus was injected into the sciatic nerve) depended on vitamin D deficiency.

It is the purpose of the present communication to record the results of a number of experiments which were designed to test the effect of ricketogenic diets, partial inanition, and sex on the susceptibility and certain immunologic responses of cotton rats to the Armstrong-Lansing strain of the virus of poliomyelitis. The results of twenty-one experiments are reported. In six of these experiments the virus was injected into the brain, in seven the virus was injected or instilled into certain parts of the alimentary tract, in two the virus was instilled into the respiratory tract, and in the six remaining experiments the virus was administered through other possible portals of entry. In most cases twenty-four cotton rats (six rachitic and six normal males, and six rachitic and six normal females) were employed in each experiment. It is felt that this particular grouping of the experimental animals should bring forward any differences in susceptibility or in immunologic responses which are due either to sex or to nutrition.

EXPERIMENTAL PROCEDURE AND RESULTS

The laboratory stock diet, fed to the normal control animals, was composed of a mixture of natural foods as follows: cane molasses, peanut oil meal, soy bean oil meal, animal liver meal, fish meal, meat

scraps, condensed buttermilk, corn gluten, wheat bran, wheat flour middlings, ground whole oats, ground whole yellow corn, ground hulled barley, ground whole wheat, whole milk powder, alfalfa leaf meal, A and D feeding oil, steamed bone meal, salt, and precipitated chalk.

The rachitogenic diet used in these experiments consisted of the following ingredients: ground whole yellow maize, 76 parts by weight; wheat gluten, 20 parts by weight; calcium carbonate (C.P.), 3 parts by weight; sodium chloride (C.P.), 1 part by weight; and dried brewer's yeast,* 0.6 part by weight.

The control animals which were fed the laboratory stock diet ad libitum thrived, presented no unusual abnormalities of the teeth and skeleton, and exhibited no particular susceptibility to intercurrent infections. Each of the normal cotton rats consumed approximately 10 Gm. of laboratory stock diet daily. On the other hand, the cotton rats which were fed the rachitogenic diet ad libitum grew only slightly, developed the marked deformities of the teeth and skeleton which are characteristic of rickets, and exhibited an increased susceptibility to respiratory infections. Each of these cotton rats consumed approximately from 5 to 6 Gm. of the rachitogenic diet daily.

The animals employed in this investigation were housed in quarters from which sunlight had been excluded and in which the temperature varied from 72 to 80° F. At intervals throughout the course of the experiment a number of the experimental animals were subjected to roentgenologic examination, and in a few animals microscopic examinations of the femurs were made. All roentgenologic and microscopic examinations were made on animals which had attained the age of 62 days, and all animals with vitamin D deficiency so examined showed unmistakable signs of rickets. No evidence of rickets could be found in the cotton rats fed the laboratory stock diet.

When each of the experimental animals which were employed in this investigation had attained the age of 32 days, it was subjected to the dietary regimen chosen for it and restricted to that diet until it was 62 days of age. At that time the virus of poliomyelitis was administered to each of the experimental animals by one of twenty-one different methods. Each rachitic cotton rat was returned to the laboratory stock diet five days after it had been inoculated with the virus. Each animal was observed morning and evening for twenty-five days following administration of the virus. Any cotton rat remaining symptom free during this interval of time was subjected to a three-way reinoculation (0.1 c.c. intracerebral, 0.06 c.c. intranasal, and 0.5 c.c. subcutaneous in the back) with a 10 per cent suspension of the virus of poliomyelitis. Any cotton rat remaining symptom free for another twenty-five days was subjected to two additional three-way reinoculations with the virus at intervals of twenty-five days. Any cotton rat failing to show symptoms of poliomyelitis following its experi-

*Vitamin D free, type 2019, Fleischmann.

mental inoculation and three three-way reinoculations with the virus was considered to be immune.

Each cotton rat in this investigation which was considered as having contracted poliomyelitis following one of the experimental inoculations with the virus, when the latter was administered by any route other than intracerebral, fulfilled the following conditions: Paralysis was apparent within twenty-five days after the virus was first administered, and observations of the animal at frequent intervals of time showed this paralysis to be progressive in nature. Samples of the central nervous system of the paralyzed animal showed histopathologic changes which are characteristic of anterior poliomyelitis. The remaining portions of the central nervous system of the paralyzed cotton rat, when made up into a 10 per cent saline suspension and injected intracerebrally into three previously untreated cotton rats, reproduced symptoms of the disease in at least one out of the three animals. At least one of the three passage animals showed histopathologic changes in its central nervous system which are characteristic of anterior poliomyelitis.

Any animal which contracted poliomyelitis after an inoculation with the virus was permitted to live twenty-four hours after paralysis was first observed with certainty. At the end of this period of time the number of extremities paralyzed was recorded and the animal was sacrificed with ether. The relative susceptibility of the cotton rats which contracted poliomyelitis following an inoculation with the virus was judged from the number of extremities paralyzed and from the length of the incubation period (number of days which elapsed between the time of inoculation with the virus and the time of death or sacrifice of the animal). Any cotton rat which developed paralysis in two or more extremities within fifteen days of an inoculation with the virus of poliomyelitis was considered as having no unusual resistance to the antigen.

The virus of poliomyelitis which was employed in these studies is the Armstrong-Lansing strain adapted to the cotton rat. During the course of the present investigation, samples of our stock virus suspensions were injected in large quantities (intracerebrally, intranasally, and subcutaneously) into albino rats, wild rats, and guinea pigs. All of these animals remained well. On the two occasions tried, samples of the stock virus suspensions produced paralytic poliomyelitis when inoculated intracerebrally into *Macaca rhesus* monkeys. In each case the spinal cords from the paralyzed monkeys produced paralytic poliomyelitis when inoculated intracerebrally into cotton rats. The unfiltered, lightly centrifuged stock suspensions of the virus employed in the present investigation have been prepared exclusively from the brain stems and spinal cords from paralyzed cotton rats which had been stored in buffered glycerine at 5° C. for a period of time not exceeding two months.

PART I. VIRUS INJECTED INTO THE BRAIN

EXPERIMENT 1.—Each cotton rat was subjected to a single three-way inoculation (0.1 c.c. intracerebral, 0.06 c.c. intranasal, and 0.5 c.c. subcutaneous in the back) with a 10 per cent suspension of the virus. This experimental group consisted of thirty-three males (thirteen rachitic and twenty normal) and thirty-seven females (twelve rachitic and twenty-five normal). Of these, two normal males and two normal females failed to contract the disease and one rachitic male developed paralysis in one extremity only; these five animals are not included in Table I, which summarizes the results of this experiment.

TABLE I

ANIMALS	AVERAGE INCUBATION PERIOD (DAYS)	EXTENT OF OBSERVABLE PARALYSIS (EXTREMITIES)
Rachitic rats	4.25 (2 to 11)	3.08 (2 to 4)
Normal rats	5.00 (2 to 13)	3.02 (2 to 4)
Males	4.83 (2 to 13)	3.07 (2 to 4)
Females	4.74 (2 to 11)	3.03 (2 to 4)
Rachitic males	4.33 (3 to 7)	3.50 (2 to 4)
Normal males	5.17 (2 to 13)	2.78 (2 to 4)
Rachitic females	4.50 (2 to 11)	2.67 (2 to 4)
Normal females	4.87 (2 to 8)	3.22 (2 to 4)

Each of the four cotton rats (two normal males and two normal females) which were resistant to their first inoculation with the virus developed paralysis in two or more extremities within a period of time equal to the usual incubation period of the virus after a three-way reinoculation with the virus.

EXPERIMENT 2.—Each cotton rat was subjected to a single intracerebral inoculation with 0.1 c.c. of a 10 per cent suspension of the virus. This experimental group consisted of twelve males (six rachitic and six normal) and twelve females (six rachitic and six normal). Of these, three normal males failed to contract the disease; these three animals are not included in Table II which summarizes the results of this experiment.

TABLE II

ANIMALS	AVERAGE INCUBATION PERIOD (DAYS)	EXTENT OF OBSERVABLE PARALYSIS (EXTREMITIES)
Rachitic rats	7.08 (2 to 12)	3.50 (2 to 4)
Normal rats	9.44 (3 to 14)	3.33 (2 to 4)
Males	8.44 (4 to 13)	3.11 (2 to 4)
Females	7.83 (2 to 14)	3.67 (2 to 4)
Rachitic males	8.17 (4 to 12)	3.00 (2 to 4)
Normal males	9.00 (6 to 13)	3.33 (2 to 4)
Rachitic females	6.00 (2 to 8)	4.00 (4)
Normal females	9.67 (3 to 14)	3.33 (2 to 4)

Of the three normal males which were resistant to their first inoculation with the virus, one contracted the disease (quadriplegia) after a prolonged incubation period (twenty days) following its second

three-way reinoculation with the virus, and the remaining two cotton rats resisted three three-way reinoculations with the virus.

EXPERIMENT 3.—Each cotton rat was subjected to a single intracerebral inoculation with 0.05 c.c. of a 10 per cent suspension of the virus. This experimental group consisted of twelve males (6 rachitic and six normal) and twelve females (six rachitic and six normal). Of these, one rachitic male, one rachitic female, and one normal female failed to contract the disease; these three animals are not included in Table III which summarizes the results of this experiment.

TABLE III

ANIMALS	AVERAGE INCUBATION PERIOD (DAYS)	EXTENT OF OBSERVABLE PARALYSIS (EXTREMITIES)
Rachitic rats	6.40 (2 to 10)	3.00 (2 to 4)
Normal rats	5.91 (3 to 8)	2.55 (2 to 4)
Males	5.91 (3 to 9)	2.73 (2 to 4)
Females	6.40 (2 to 10)	2.80 (2 to 4)
Rachitic males	6.40 (4 to 9)	3.60 (2 to 4)
Normal males	5.50 (3 to 8)	2.00 (2)
Rachitic females	6.40 (2 to 10)	2.40 (2 to 4)
Normal females	6.40 (4 to 8)	3.20 (2 to 4)

Of the three animals which were resistant to their first inoculations with the virus, one normal female contracted the disease (quadriplegia) within a period of time equal to the usual incubation period of the virus, after its first three-way reinoculation, whereas one rachitic male and one rachitic female resisted three three-way reinoculations with the virus.

EXPERIMENT 4.—Each cotton rat was subjected to a single intracerebral inoculation with 0.05 c.c. of a 5 per cent suspension of the virus. This experimental group consisted of twelve males (six rachitic and six normal) and twelve females (six rachitic and six normal). Each of the animals in this group contracted the disease. Table IV summarizes the results of this experiment.

TABLE IV

ANIMALS	AVERAGE INCUBATION PERIOD (DAYS)	EXTENT OF OBSERVABLE PARALYSIS (EXTREMITIES)
Rachitic rats	5.17 (3 to 9)	2.83 (2 to 4)
Normal rats	4.17 (2 to 8)	3.00 (2 to 4)
Males	4.25 (2 to 7)	2.67 (2 to 4)
Females	5.08 (3 to 9)	3.17 (2 to 4)
Rachitic males	4.83 (3 to 6)	2.67 (2 to 4)
Normal males	3.67 (2 to 7)	2.67 (2 to 4)
Rachitic females	5.50 (3 to 9)	3.00 (2 to 4)
Normal females	4.67 (3 to 8)	3.33 (2 to 4)

EXPERIMENT 5.—Each cotton rat was subjected to a single intracerebral inoculation with 0.05 c.c. of a 1 per cent suspension of the virus. This experimental group consisted of twelve males (six rachitic and six normal) and twelve females (six rachitic and six normal). Of these, one rachitic male, one rachitic female, and one normal female

failed to contract the disease, and one normal male and one normal female contracted the disease only after a prolonged incubation period (these five animals are not included in Table V which summarizes the results of this experiment).

TABLE V

ANIMALS	AVERAGE INCUBATION PERIOD (DAYS)	EXTENT OF OBSERVABLE PARALYSIS (EXTREMITIES)
Rachitic rats	6.80 (3 to 11)	3.20 (2 to 4)
Normal rats	7.56 (3 to 12)	3.11 (2 to 4)
Males	7.30 (4 to 12)	3.00 (2 to 4)
Females	7.00 (3 to 12)	3.33 (2 to 4)
Rachitic males	7.20 (6 to 8)	2.80 (2 to 4)
Normal males	7.40 (4 to 12)	3.20 (2 to 4)
Rachitic females	6.40 (3 to 11)	3.60 (2 to 4)
Normal females	7.77 (3 to 12)	3.00 (2 to 4)

Of the three animals which were resistant to their first inoculation with the virus, one rachitic male and one normal female contracted the disease (quadriplegia) within a period of time equal to the usual incubation period of the virus after they had received their first three-way reinoculation, whereas one rachitic female resisted three three-way reinoculations with the virus.

EXPERIMENT 6.—Each cotton rat was subjected to a single intracerebral inoculation with 0.05 c.c. of a 0.1 per cent suspension of the virus. This experimental group consisted of twelve males (six rachitic and six normal) and twelve females (six rachitic and six normal). Of these, three rachitic males, three normal males, two rachitic females, and one normal female failed to contract the disease, and one rachitic female became paralyzed in one extremity only; these ten animals are not included in Table VI which summarizes the results of this experiment.

TABLE VI

ANIMALS	AVERAGE INCUBATION PERIOD (DAYS)	EXTENT OF OBSERVABLE PARALYSIS (EXTREMITIES)
Rachitic rats	7.33 (3 to 11)	3.67 (2 to 4)
Normal rats	8.00 (4 to 12)	3.75 (2 to 4)
Males	8.00 (3 to 12)	3.33 (2 to 4)
Females	7.50 (3 to 11)	4.00 (4)
Rachitic males	7.00 (3 to 11)	3.33 (2 to 4)
Normal males	9.00 (6 to 12)	3.33 (2 to 4)
Rachitic females	7.67 (3 to 11)	4.00 (4)
Normal females	7.40 (4 to 10)	4.00 (4)

Of the nine animals which were resistant to their first inoculation with the virus, three rachitic males and one normal male developed quadriplegia, and two rachitic females developed monoplegia within a period of time equal to the usual incubation period of the virus after they had received their first three-way reinoculation; one normal male developed diplegia within a period of time equal to the usual incubation period of the virus after it had been subjected to its second three-way reinoculation and one normal male and one normal female resisted three three-way reinoculations with the virus.

SUMMARY OF PART I (EXPERIMENTS 1 TO 6)

It appears to be advisable to group together in summary fashion the results of the first six experiments during the course of which cotton rats were subjected to intracerebral inoculations with varying quantities of the virus of poliomyelitis. The number of animals employed were ninety-three males (forty-three rachitic and fifty normal) and ninety-seven females (forty-two rachitic and fifty-five normal). Table VII summarizes the results of Experiments 1 to 6.

TABLE VII

ANIMALS	PARALYZED IN TWO OR MORE EXTREMITIES WITHIN USUAL INCUBATION PERIOD			RESISTANT TO THREE THREE-WAY REINOCULATIONS
	AFTER EXPERIMENTAL INOCULATION	AFTER FIRST REINOCULATION	AFTER SECOND REINOCULATION	
Rachitic males (43)	1* 37	4		1
Normal males (50)	1† 41	3	1† 1	3
Rachitic females (42)	1* 37	2		2
Normal females (55)	1† 49	4		1

*Paralyzed in one extremity only.
†Contracted disease after prolonged incubation period.

The average incubation period and extent of the paralysis observed in the animals which contracted the disease after an experimental inoculation with the virus (Experiments 1 to 6) are summarized in Table VIII.

TABLE VIII

ANIMALS	NUMBER OF ANIMALS	AVERAGE INCUBATION PERIOD (DAYS)	EXTENT OF OBSERVABLE PARALYSIS (EXTREMITIES)
Rachitic rats	74	5.80 (2 to 12)	3.17 (2 to 4)
Normal rats	90	5.88 (2 to 14)	3.04 (2 to 4)
Males	78	5.77 (2 to 13)	2.98 (2 to 4)
Females	86	5.91 (2 to 14)	3.21 (2 to 4)
Rachitic males	37	5.92 (3 to 12)	3.19 (2 to 4)
Normal males	41	5.83 (2 to 13)	2.78 (2 to 4)
Rachitic females	37	5.68 (2 to 11)	3.14 (2 to 4)
Normal females	49	6.08 (2 to 14)	3.26 (2 to 4)

The results of these experiments indicate that rachitogenic diets, partial inanition, and sex have no appreciable effect on the susceptibility of cotton rats to the Armstrong-Lansing strain of the virus of poliomyelitis when the latter is injected directly into the brain. It would appear further that rachitogenic diets, partial inanition, and sex have no influence on the capacities of cotton rats so treated to resist subsequent three-way reinoculations with potent suspensions of the virus.

PART II. VIRUS INJECTED OR INSTILLED INTO ALIMENTARY TRACT

EXPERIMENT 7.—Each cotton rat devoured one brain stem and spinal cord which had been freshly removed from a cotton rat paralyzed with poliomyelitis. This experimental group consisted of twelve males (six rachitic and six normal) and twelve females (six rachitic and six normal). Table IX summarizes the results of this experiment.

TABLE IX

ANIMALS	PARALYZED IN TWO OR MORE EXTREMITIES WITHIN USUAL INCUBATION PERIOD			RESISTANT TO THREE THREE-WAY INOCULATIONS
	AFTER EXPERIMENTAL INOCULATION	AFTER FIRST REINOCULATION	AFTER SECOND REINOCULATION	
Rachitic males	0	6		
Normal males	0	6		
Rachitic females	0	5		1
Normal females	0	5		1

EXPERIMENT 8.—Each cotton rat received a submucosal injection of 0.5 c.c. of a 10 per cent suspension of virus into each of the two regions which in certain animals other than cotton rats house the palatine tonsils. The experimental group consisted of twelve males (six rachitic and six normal) and twelve females (six rachitic and six normal). Table X summarizes the results of this experiment.

TABLE X

ANIMALS	PARALYZED IN TWO OR MORE EXTREMITIES WITHIN USUAL INCUBATION PERIOD			RESISTANT TO THREE THREE-WAY REINOCULATIONS
	AFTER EXPERIMENTAL INOCULATION	AFTER FIRST REINOCULATION	AFTER SECOND REINOCULATION	
Rachitic males	0			6
Normal males	0			6
Rachitic females	1			5
Normal females	1	1*		4

*Paralyzed in one extremity only.

EXPERIMENT 9.—Each cotton rat was subjected to a single intragastric instillation of 1.0 c.c. of a 10 per cent suspension of the virus administered by means of a stomach tube. This experimental group consisted of twelve males (six rachitic and six normal) and twelve females (six rachitic and six normal). Table XI summarizes the results of this experiment.

TABLE XI

ANIMALS	PARALYZED IN TWO OR MORE EXTREMITIES WITHIN USUAL INCUBATION PERIOD			RESISTANT TO THREE THREE-WAY REINOCULATIONS
	AFTER EXPERIMENTAL INSTILLATION	AFTER FIRST REINOCULATION	AFTER SECOND REINOCULATION	
Rachitic males	0	3		3
Normal males	0	6		
Rachitic females	0	5		1
Normal females	0	4		2

EXPERIMENT 10.—Each cotton rat was subjected on each of three successive days to a single intragastric instillation of 1.0 c.c. of a 10 per cent suspension of the virus administered by means of a stomach tube. This experimental group consisted of twelve males (six rachitic and six normal) and twelve females (six rachitic and six normal). Table XII summarizes the results of this experiment.

TABLE XII

ANIMALS	PARALYZED IN TWO OR MORE EXTREMITIES WITHIN USUAL INCUBATION PERIOD			RESISTANT TO THREE THREE-WAY REINOCULATIONS
	AFTER EXPERIMENTAL INSTILLATION	AFTER FIRST REINOCULATION	AFTER SECOND REINOCULATION	
Rachitic males	0	4		2
Normal males	0	1*	1	
		4		
Rachitic females	0	5		1
Normal females	0	3	1	2

*Paralyzed in one extremity only.

EXPERIMENT 11.—Each cotton rat was subjected on each of three successive days to a single intracolonic instillation of 1.0 c.c. of a 10 per cent suspension of the virus administered by means of a rectal tube. This experimental group consisted of twelve males (six rachitic and six normal) and twelve females (six rachitic and six normal). Table XIII summarizes the results of this experiment.

TABLE XIII

ANIMALS	PARALYZED IN TWO OR MORE EXTREMITIES WITHIN USUAL INCUBATION PERIOD			RESISTANT TO THREE THREE-WAY REINOCULATIONS
	AFTER EXPERIMENTAL INSTILLATION	AFTER FIRST REINOCULATION	AFTER SECOND REINOCULATION	
Rachitic males	0	5		1
Normal males	0	4		2
Rachitic females	0	2*		1
		3		
Normal females	0	5		1

*Paralyzed in one extremity only.

EXPERIMENT 12.—Each cotton rat was subjected to a single intraperitoneal inoculation with 0.5 c.c. of a 10 per cent suspension of the virus. This experimental group consisted of twelve males (six rachitic and six normal) and twelve females (six rachitic and six normal). Table XIV summarizes the results of this experiment.

TABLE XIV

ANIMALS	PARALYZED IN TWO OR MORE EXTREMITIES WITHIN USUAL INCUBATION PERIOD			RESISTANT TO THREE THREE-WAY REINOCULATIONS
	AFTER EXPERIMENTAL INOCULATION	AFTER FIRST REINOCULATION	AFTER SECOND REINOCULATION	
Rachitic males	0			6
Normal males	0			6
Rachitic females	0	2		4
Normal females	0	3		3

EXPERIMENT 13.—Each cotton rat was subjected on each of three successive days to a single intraperitoneal inoculation with 1.0 c.c. of a 10 per cent suspension of the virus. This experimental group consisted of twelve males (six rachitic and six normal) and twelve females (six rachitic and six normal). Table XV summarizes the results of this experiment.

TABLE XV

ANIMALS	PARALYZED IN TWO OR MORE EXTREMITIES WITHIN USUAL INCUBATION PERIOD			RESISTANT TO THREE THREE-WAY REINOCULATIONS
	AFTER EXPERIMENTAL INOCULATION	AFTER FIRST REINOCULATION	AFTER SECOND REINOCULATION	
Rachitic males			1	5
Normal males	1*			5
Rachitic females				6
Normal females				6

*Contracted disease after prolonged incubation period.

SUMMARY OF PART II (EXPERIMENTS 7 TO 13)

The number of animals employed in the experiments in which the virus was injected or instilled into parts of the alimentary tract included eighty-four males (forty-two rachitic and forty-two normal) and eighty-four females (forty-two rachitic and forty-two normal). Of these, one normal male, one rachitic female, and one normal female contracted the disease following the experimental inoculation with the virus. Table XVI summarizes the results of Experiments 7 to 13.

TABLE XVI

ANIMALS	PARALYZED IN TWO OR MORE EXTREMITIES WITHIN USUAL INCUBATION PERIOD			RESISTANT TO THREE THREE-WAY REINOCULATIONS
	AFTER EXPERIMENTAL INOCULATION	AFTER FIRST REINOCULATION	AFTER SECOND REINOCULATION	
Rachitic males (42)		18	1	23
Normal males (42)	1†	1* 20	1	19
Rachitic females (42)	1	2* 20		19
Normal females (42)	1	1* 20	1	19

*Paralyzed in one extremity only.
†Contracted disease after prolonged incubation period.

The results of these experiments indicate that rachitogenic diets, partial inanition, and sex have no appreciable effect on the susceptibility of cotton rats to the Armstrong-Lansing strain of the virus of poliomyelitis when the latter is ingested, injected beneath the mucous membrane in the tonsillar areas, instilled into the stomach and into the colon, or injected into the peritoneal cavity. It would appear further that rachitogenic diets, partial inanition, and sex have no influence on

the capacities of cotton rats so treated to resist subsequent three-way reinoculations with potent suspensions of the virus. In addition, these experiments indicate that in the cotton rat the alimentary tract may be occasionally the portal of entry of the Armstrong-Lansing strain of the virus of poliomyelitis.

PART III. VIRUS INSTILLED INTO RESPIRATORY TRACT

EXPERIMENT 14.—Each cotton rat was subjected during the morning and again during the evening on each of three successive days to an intranasal instillation with the virus of poliomyelitis. On each of these occasions 0.05 c.c. of a 10 per cent suspension of the virus was dropped into each nostril. This experimental group consisted of twelve males (six rachitic and six normal) and twelve females (six rachitic and six normal). Table XVII summarizes the results of this experiment.

TABLE XVII

ANIMALS	PARALYZED IN TWO OR MORE EXTREMITIES WITHIN USUAL INCUBATION PERIOD			RESISTANT TO THREE THREE-WAY REINOCULATIONS
	AFTER EXPERIMENTAL INSTILLATION	AFTER FIRST REINOCULATION	AFTER SECOND REINOCULATION	
Rachitic males	0	4	1	1
Normal males	0	3	1	2
Rachitic females	1	1*		
		4		
Normal females	0	4	1	1

*Paralyzed in one extremity only after a prolonged incubation period.

EXPERIMENT 15.—Each cotton rat was subjected to a single intrapulmonary instillation of 0.08 c.c. of a concentrated virus suspension administered by means of a tracheal catheter. Each 0.08 c.c. of this ether-washed and vacuum-concentrated suspension was prepared in such a way as to contain the active principle in 1.0 c.c. of a 10 per cent suspension. Quantities as low as 0.01 c.c. of this concentrated suspension regularly produced paralysis when inoculated intracerebrally into previously untreated cotton rats. This experimental group consisted of twelve males (six rachitic and six normal) and twelve females (six rachitic and six normal). Table XVIII summarizes the results of this experiment.

TABLE XVIII

ANIMALS	PARALYZED IN TWO OR MORE EXTREMITIES WITHIN USUAL INCUBATION PERIOD			RESISTANT TO THREE THREE-WAY REINOCULATIONS
	AFTER EXPERIMENTAL INSTILLATION	AFTER FIRST REINOCULATION	AFTER SECOND REINOCULATION	
Rachitic males	0	3		3
Normal males	0	2		4
Rachitic females	0	2*		2
		2		
Normal females	0	2		4

*Paralyzed in one extremity only.

SUMMARY OF PART III (EXPERIMENTS 14 AND 15)

The number of animals employed in the experiments related to the respiratory tract include twenty-four males (twelve rachitic and twelve normal) and twenty-four females (twelve rachitic and twelve normal). Of these, one rachitic female only contracted the disease. Table XIX summarizes the results of Experiments 14 and 15.

TABLE XIX

ANIMALS	PARALYZED IN TWO OR MORE EXTREMITIES WITHIN USUAL INCUBATION PERIOD			RESISTANT TO THREE THREE-WAY REINOCULATIONS
	AFTER EXPERIMENTAL INSTILLATION	AFTER FIRST REINOCULATION	AFTER SECOND REINOCULATION	
Rachitic males (12)	0	7	1	4
Normal males (12)	0	5	1	6
Rachitic females (12)	1	1* 2† 6		2
Normal females (12)	0	6	1	5

*Paralyzed in one extremity only after a prolonged incubation period.
†Paralyzed in one extremity only.

The results of these experiments indicate that rachitogenic diets, partial inanition, and sex have no appreciable effect on the susceptibility of cotton rats to the Armstrong-Lansing strain of the virus of poliomyelitis when the latter is instilled into the external nares or bronchi. It would appear further that rachitogenic diets, partial inanition, and sex have little, if any, influence on the abilities of cotton rats so treated to resist subsequent three-way reinoculations with potent suspensions of the virus. In addition these experiments indicate that in the cotton rat the respiratory tract may be occasionally the portal of entry of the Armstrong-Lansing strain of the virus of poliomyelitis.

PART IV. VIRUS ADMINISTERED THROUGH OTHER POSSIBLE PORTALS OF ENTRY

EXPERIMENT 16.—Each cotton rat was subjected to a single subcutaneous inoculation with 1.0 c.c. of a 10 per cent suspension of the virus. This experimental group consisted of twelve males (six ricketic

TABLE XX

ANIMALS	PARALYZED IN TWO OR MORE EXTREMITIES WITHIN USUAL INCUBATION PERIOD			RESISTANT TO THREE THREE-WAY REINOCULATIONS
	AFTER EXPERIMENTAL INOCULATION	AFTER FIRST REINOCULATION	AFTER SECOND REINOCULATION	
Rachitic males	0	1		5
Normal males	0	1	1	4
Rachitic females	0			6
Normal females	0			6

and six normal) and twelve females (six ricketic and six normal). Table XX summarizes the results of this experiment.

EXPERIMENT 17.—Each cotton rat was subjected on each of three successive days to a single subcutaneous inoculation with 1.0 c.c. of a 10 per cent suspension of the virus. This experimental group consisted of twelve males (six rachitic and six normal) and twelve females (six rachitic and six normal). Table XXI summarizes the results of this experiment.

TABLE XXI

ANIMALS	PARALYZED IN TWO OR MORE EXTREMITIES WITHIN USUAL INCUBATION PERIOD			RESISTANT TO THREE THREE-WAY REINOCULATIONS
	AFTER EXPERIMENTAL INOCULATION	AFTER FIRST REINOCULATION	AFTER SECOND REINOCULATION	
Rachitic males	0	1		5
Normal males	0			6
Rachitic females	0			6
Normal females	0		1	5

EXPERIMENT 18.—Each cotton rat was subjected to a single intracardiac inoculation with 1.0 c.c. of a 10 per cent ether-washed suspension of the virus. This experimental group consisted of six males (three rachitic and three normal) and four females (two rachitic and two normal). Table XXII summarizes the results of this experiment.

TABLE XXII

ANIMALS	PARALYZED IN TWO OR MORE EXTREMITIES WITHIN USUAL INCUBATION PERIOD			RESISTANT TO THREE THREE-WAY REINOCULATIONS
	AFTER EXPERIMENTAL INOCULATION	AFTER FIRST REINOCULATION	AFTER SECOND REINOCULATION	
Rachitic males	0			3
Normal males	1			2
Rachitic females	0			2
Normal females	0			2

EXPERIMENT 19.—Each cotton rat was subjected to a single intracardiac inoculation with 0.5 c.c. of a 10 per cent ether-washed suspension of the virus. This experimental group consisted of twelve males (six rachitic and six normal) and twelve females (six rachitic and six normal). Table XXIII summarizes the results of this experiment.

TABLE XXIII

ANIMALS	PARALYZED IN TWO OR MORE EXTREMITIES WITHIN USUAL INCUBATION PERIOD			RESISTANT TO THREE THREE-WAY REINOCULATIONS
	AFTER EXPERIMENTAL INOCULATION	AFTER FIRST REINOCULATION	AFTER SECOND REINOCULATION	
Rachitic males	0			6
Normal males	0			6
Rachitic females	1			5
Normal females	0			6

EXPERIMENT 20.—Each cotton rat was subjected to a single intracardiac inoculation with 0.08 c.c. of a concentrated virus suspension. Each 0.08 c.c. of this ether-washed and vacuum-concentrated suspension was prepared in such a way as to contain the active principle in 1.0 c.c. of a 10 per cent suspension. Quantities as low as 0.01 c.c. of this concentrated suspension regularly produced paralysis when inoculated intracerebrally into previously untreated cotton rats. This experimental group consisted of twelve males (six rachitic and six normal) and twelve females (six rachitic and six normal). Table XXIV summarizes the results of this experiment.

TABLE XXIV

ANIMALS	PARALYZED IN TWO OR MORE EXTREMITIES WITHIN USUAL INCUBATION PERIOD			RESISTANT TO THREE THREE-WAY REINOCULATIONS
	AFTER EXPERIMENTAL INOCULATION	AFTER FIRST REINOCULATION	AFTER SECOND REINOCULATION	
Rachitic males	0	1*		3
		2		
Normal males	0	2		4
Rachitic females	0	1		5
Normal females	0	1*	1†	2
		2		

*Paralyzed in one extremity only.
†Contracted disease after prolonged incubation period.

EXPERIMENT 21.—Each cotton rat was permitted to live in the same cage with another cotton rat which had been subjected to a three-way inoculation with the virus. The experimental cotton rat remained in intimate contact with the inoculated animal until the latter became completely paralyzed. This experimental group consisted of twelve males (six rachitic and six normal) and twelve females (six rachitic and six normal). Table XXV summarizes the results of this experiment.

TABLE XXV

ANIMALS	PARALYZED IN TWO OR MORE EXTREMITIES WITHIN USUAL INCUBATION PERIOD			RESISTANT TO THREE THREE-WAY REINOCULATIONS
	AFTER EXPERIMENTAL EXPOSURE	AFTER FIRST REINOCULATION	AFTER SECOND REINOCULATION	
Rachitic males	0	6		
Normal males	0	5		1
Rachitic females	0	5		1
Normal females	0	4		2

SUMMARY OF PART IV (EXPERIMENTS 16 TO 21)

The results of these experiments indicate that rachitogenic diets, partial inanition, and sex have no appreciable effect on the susceptibility of cotton rats to the Armstrong-Lansing strain of the virus of poliomyelitis when the latter is inoculated beneath the skin, directly into the blood stream, or acquired through contact with an infected

animal. It would appear further that rachitogenic diets, partial inanition, and sex have no influence on the abilities of cotton rats so treated to resist subsequent three-way reinoculations with potent suspensions of the virus. Finally, these experiments demonstrate that in the cotton rat paralytic poliomyelitis may occasionally follow the injection of large quantities of the virus into the blood stream. We have not succeeded in producing the disease in the cotton rat as a consequence of injecting large quantities of the virus beneath the skin of the back or by permitting an animal to remain in intimate contact with a cotton rat which is succumbing with the disease.

DISCUSSION

The present communication records the results of twenty-one experiments which were designed to test the effect of rachitogenic diets, partial inanition, and sex on the susceptibility and certain immunologic responses of cotton rats to the Armstrong-Lansing strain of the virus of poliomyelitis. With two exceptions, twenty-four cotton rats (six rachitic and six normal males and six rachitic and six normal females) were employed in each experiment. The cotton rats subsisting on the rachitogenic diets consumed only from 50 to 60 per cent as much food as did the normal controls. During the course of this investigation suspensions of the virus were injected or instilled in varying quantities into the cerebrum, stomach, colon, peritoneal cavity, external nares, primary bronchi, blood stream, beneath the skin of the back, and beneath the mucous membrane in the regions which in certain animals other than cotton rats house the palatine tonsils. In addition, the animals on one experimental group were allowed to live in intimate contact with other cotton rats which had been subjected to intracerebral inoculations with the virus. Finally, cotton rats of one experimental group were allowed to devour the brain stem and spinal cord freshly removed from a cotton rat paralyzed with poliomyelitis. Three-way reinoculations with potent suspensions of the virus of poliomyelitis were administered at intervals of twenty-five days to each of the cotton rats which failed to exhibit paralysis following an experimental inoculation with the virus.

In none of these experiments was there any indication that avitaminosis D, partial inanition, or sex altered significantly the susceptibility of cotton rats to the Armstrong-Lansing strain of the virus of poliomyelitis. Furthermore, in no case did any of these experiments yield any evidence suggesting that avitaminosis D, partial inanition, or sex has any appreciable influence on the abilities of cotton rats to develop resistance to three-way reinoculations with the virus when the latter were administered subsequent to any of the experimental inoculations employed in this investigation.

The results of the present investigation offer no evidence in support of the concept that transmission of the virus of poliomyelitis along

peripheral myelinated nerves is dependent on, or at least facilitated by, avitaminosis D. In our experiments we have been unable to produce paralysis in rachitic cotton rats by injecting suspensions of the virus into the subcutaneous tissues in the region of the back. In these particular experiments, subdermal pools of virus remained for an appreciable length of time within 1 cm. of the dorsal root ganglia and within tissues abundantly supplied with myelinated nerve fibers.

The present investigation indicates that in the cotton rat the Armstrong-Lansing strain of the virus of poliomyelitis produces paralysis only occasionally when it is introduced by any route other than by injections directly into the cerebrum. In six cases only were we successful in producing an infection of the central nervous tissues by injecting extracerebrally large quantities of the virus; namely, intracardiac (two cases), intraperitoneal (one case), intranasal (one case), and intratonsillar (two cases).

The results of the experiments reported in this communication reveal that cotton rats develop, in an overwhelming majority of the cases, a solid resistance to three-way inoculations with the virus when the latter are administered after the animals have been subjected to intratonsillar, intraperitoneal, intracardiac, or subcutaneous inoculations with relatively large quantities of potent suspensions of the Armstrong-Lansing strain of the virus of poliomyelitis. A lesser percentage of cotton rats develops this resistance following intrapulmonary, intranasal, intracolonic, or intragastric instillations of relatively large quantities of the virus, after contact with a cotton rat succumbing to the disease, or after devouring a brain stem and spinal cord which had been infected with the virus of poliomyelitis.

SUMMARY AND CONCLUSIONS

The results of twenty-one experiments designed to test the effect of rachitogenic diets, partial inanition and sex on the susceptibility and certain immunologic responses of cotton rats to the virus of poliomyelitis are reported. With two exceptions, each experimental group of animals consisted of twenty-four cotton rats (six rachitic and six normal males and six rachitic and six normal females).

During the present investigation suspensions of the Armstrong-Lansing strain of the virus of poliomyelitis were injected or instilled in varying quantities into the cerebrum, stomach, colon, peritoneal cavity, external nares, primary bronchi, blood stream, beneath the skin of the back, and beneath the mucous membranes in the regions which in certain animals other than cotton rats house the palatine tonsils. In addition, the animals of one experimental group were allowed to remain in intimate contact with cotton rats which were succumbing from the effects of intracerebral inoculations with the virus. Finally, each cotton rat of still another experimental group was fed the brain stem and spinal cord freshly removed from a cotton rat paralyzed with poliomyelitis.

Each of the cotton rats which failed to exhibit paralysis following an experimental inoculation with the virus was subjected to three-way reinoculations with the virus at intervals of twenty-five days.

The results of the experiments reported in this communication yield no evidence indicating that avitaminosis D, partial inanition, or sex alters significantly the susceptibility of cotton rats to the Armstrong-Lansing strain of the virus of poliomyelitis. Furthermore, there was no indication that the abilities of cotton rats to develop resistance to three-way reinoculations with the virus, when the latter were administered subsequent to any of the experimental inoculations, are influenced by avitaminosis D, partial inanition, or sex.

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The Pediatrician and the War

The following is a continuation list of Fellows of the American Academy of Pediatrics on active duty in the military services:

Army

E. A. Hagmann, Billings, Mont. (Major)

Navy

Herbert L. Elias, Long Island, N. Y. (Lieutenant Commander)

John Robert Gilmour, East Orange, N. J. (Lieutenant)

At the annual meeting of the Executive Board of the American Academy of Pediatrics in November, the subject of *Emergency Maternal* and *Infant Welfare* was discussed in length. A resolution was finally adopted, asking the Children's Bureau to call a meeting of official representatives from certain designated medical organizations and other organizations interested in and involved in this legislation which has been the subject of much controversy.

In response to the Academy request a conference was held in Washington, Dec. 10 and 11, 1943, with representatives present from American Medical Association, American Hospital Association, U. S. Public Health Service, American Association of Obstetricians, Gynecologists and Abdominal Surgeons, American Academy of Pediatrics, American Gynecological Society, American Pediatric Society, Committee of Physicians for the Improvement of Medical Care, Association of State and Territorial Health Officers, War Department, Navy Department, Army Emergency Relief, Navy Relief Society, American Red Cross, American Legion and the Washington representatives of five national women's organizations that have supported the legislation. The Children's Bureau also invited the medical and public health members of the Children's Bureau Advisory Committee on Maternal and Child Health Services. Dr. Martha M. Eliot, associate chief of the Children's Bureau, served as chairman of the conference.

Dr. Joseph Wall, President Elect, and Dr. Clifford Grulee represented the American Academy of Pediatrics.

The following is taken from a statement of the conference issued by the Children's Bureau:

The first day of the conference was given over to a full discussion by the official delegates of the various organizations of the purpose of the emergency maternity and infant care program as provided for in the acts of Congress and the policies under which the program is being administered by the Children's Bureau.

Miss Lenroot, in response to inquiries as to whether the Children's Bureau regarded the program as an emergency program or one that would be continued after the war, stated that since the appropriations made by the Congress for emergency maternal and infant care were national defense items, the Secretary of Labor, in her regulations governing allotments of these funds, had specified that "the term 'emergency' refers to the period of the present war and six months following its termination."

The question as to whether the program should be changed from one of payments for medical, hospital and nursing care to one of cash grants to the wives of enlisted men was discussed fully by representatives of the medical profession and by representatives of the Army, the Navy and the various organizations concerned with dependents of servicemen. The present policy of Congress in providing for medical hospital and nursing care instead of cash grants was supported in discussion by the representatives of the servicemen and by various organizations concerned with the welfare of the wives and infants of the enlisted men and by some of the medical and public health members of the conference. Since the Children's Bureau has no jurisdiction in this matter but must administer the program in accordance with the act of Congress and provide care rather than cash grants, the issue was not acted upon by the conference.

On the second day, therefore, attention was turned to the policies adopted by the Children's Bureau in the administration of the program. After full discussion of the question as to whether physicians should be permitted to charge fees in addition to payments made by the state health agencies for services rendered under the program, the conference agreed without dissent that "suplementary payment to the physician by the patient for services authorized should not be allowed."

It will be of interest to physicians that the conference also concurred in the following policies relating to administration of the program.

The hospital, if hospital care is requested, agrees to accept payment only from the state health agency for services rendered under the program and will provide at least ten days' care following delivery if accommodations are available and the patient wishes to remain in the hospital.

The hospital will provide special accommodations or services as indicated by the patient's medical condition in return for the per diem payment made by the state health agency.

The wife of an enlisted man may have free choice under the program of all types of available facilities and services including private practitioners, clinics, hospitals and other health facilities that meet the standards established under a state plan for each type of service or facility.

The cost of medical services in a clinic and/or hospital, including maintenance and salaries, where such medical service is provided by staff physicians (such as interns, resident staff and attending physicians employed by or appointed to the staff of clinic or hospital) must be included in the calculation of the cost per clinic visit and the "ward-cost-per-patient-day" (as outlined by the Children's Bureau in the memorandum of Sept. 1, 1943).

Individuals accepted for care under the program will be routinely referred to local public health agencies for the provision of whatever public health nursing services can be made available.

Arrangements will be made to utilize community facilities including appropriate social and health agencies to meet needs other than those provided for under the emergency maternal and infant care program for wives and infants of enlisted men.

There was also discussion with respect to methods of payment and the scope of the service included under the plan. The discussion brought out that it is the intent of Congress that there shall be no financial investigations for eligibility for care under the program. The program provides for complete maternity care and for the consultation of specialists and other special services in accordance with the medical need of the wife or infant.

The revised policies will be distributed to the state health agencies and published in full in J. A. M. A.

At the close of the meeting the following resolution offered by a representative of the American Academy of Pediatrics was adopted:

WHEREAS, The free expression of opinion during this conference from official representatives of all interested agencies has been of the greatest value in securing a better understanding and cooperation of those interested in the health and welfare of the wives and infants of the members of our armed forces, and

WHEREAS, The Children's Bureau, a governmental agency, has wisely acceded to the request of the Academy of Pediatrics to call this initial conference with the official representatives of the professions actually rendering service under the E. M. I. C. plan and to consider the problems arising from the application of this plan, be it

Resolved, That it is the sense of this assembly, in view of the extraordinary benefits which have accrued by a meeting of those representing many thousands of servicemen, health professional and lay organizations that future governmental conferences, national, state and local, involving medical services, be similarly composed of the official representatives of professions rendering these services and of the groups receiving them and thereby create in the public interest mutual confidence, cooperation and good will between governmental and medical agencies.

American Academy of Pediatrics

Proceedings

TWELFTH ANNUAL MEETING OF THE AMERICAN ACADEMY OF PEDIATRICS

CHICAGO, ILL., NOV. 4-7, 1942

State Chairmen's Round Table Discussion

Chairman: Lee Forrest Hill, M.D., Chairman of Region III, Des Moines, Iowa

Associates: Edward C. Mitchell, M.D., President American Academy of Pediatrics; Liaison officer with American Legion
Clifford G. Grulee, M.D., Secretary of the American Academy of Pediatrics, Evanston, Ill.
Martha Eliot, M.D., Associate Chief Children's Bureau, Washington, D. C.
Stanley H. Nichols, M.D., Chairman of Region I, Asbury Park, N. J.
Sterling H. Ashmun, M.D., State Chairman for Ohio, Dayton, Ohio
Fairfax Hall, M.D., Chairman of the National Committee on Contact Infections, New Rochelle, N. Y.
Albert D. Kaiser, M.D., Chairman of the National Committee on Cooperation with Non-Medical Groups and Societies, Rochester, N. Y.

Secretary: George F. Munns, M.D., Associate Chairman of Region III, Winnetka, Ill.

CHAIRMAN HILL.—This round table discussion has been arranged by the Program Committee as the result of numerous requests by state chairmen for a longer period than has been allotted at previous national meetings of the Academy for discussion of problems of interest to state chairmen. As chairman I felt it was important to find out what you wanted to talk about. Many of you expressed interest in having the duties of a state chairman discussed. To answer this question I could think of no one better qualified than our secretary, who was one of the originators of the Academy and who has been intimately associated with its organizational setup ever since.

DR. GRULEE.—Dr. Grulee announced that for the duration there would be no further national or regional meetings, and during this time the state chairmen's organization would carry on the work of the Academy. He called attention to the Manual for State Chairmen, recently compiled by Dr. Martmer, and urged that all state chairmen send in for a copy. Dr. Grulee emphasized that the strength of the Academy is entirely dependent on the activities and opinions of qualified pediatricians of the United States. It is the duty of the state chairmen to promote the activities of the national committees of the Academy. That has been done in some states and neglected in others. He urged that the state chairmen organize the practice of pediatrics in their respective states and include men who are interested in the practice but who are not members of the Academy.

CHAIRMAN HILL.—If any of you have questions, I am sure Dr. Grulee will be glad to answer them at this time.

QUESTION.—Do local state organizations detract from the influence of the Academy?

ANSWER.—No. They usually advance the influence.

QUESTION.—Who appoints the committee members?

ANSWER.—The state chairman.

QUESTION.—May men who are not members of the Academy do some of the work of the Academy?

ANSWER.—This may be necessary in states where the members are too few to secure good results.

QUESTION.—Since our regional and national meetings are to be suspended, by what organization should the business of the Academy be carried on?

ANSWER.—The business of the Academy should be carried on by the executive board and by the state chairmen.

QUESTION.—For how long a period of service are state chairmen appointed?

ANSWER.—State chairmen serve as long as they are efficient in their office, if they so desire. Reappointment is made on recommendation of the regional chairman.

CHAIRMAN HILL.—Our next speaker has served long and efficiently as Chairman of Region I.

DR. NICHOLS.—From the broad point of view, the principal aim of regional and state chairmen should be to perfect local organizations for the purpose of carrying out the objectives of the American Academy of Pediatrics as set forth in the constitution, particularly in Section I of Article III:

> The object of the Academy shall be to foster and stimulate interest in Pediatrics and correlate all aspects of the work for the welfare of children which properly come within the scope of Pediatrics.

Child health needs are not the same in all states. Consequently the needs in each state should be carefully studied, and close cooperation should exist between the regional and state chairmen in taking steps to meet those needs. Each state chairman should see to it that all qualified pediatricians residing in his state are given the opportunity of becoming Academy members if they so desire. The appointment of local committees for carrying out Academy objectives is an important function of the state chairman. In so far as possible, all Academy members should from time to time hold a useful Child Health Committee position. Not only does this procedure contribute to furthering the objectives of the American Academy of Pediatrics, but it also stimulates the feeling on the part of the Fellow that he is an integral and important unit in the Academy as a whole. Moreover, committee assignments should not be restricted strictly to those committees which originate in the Academy itself. Every effort should be made to have Academy representation on all groups within the state which carry on child health activities. Among such groups may be mentioned state medical societies, state departments of health, state welfare departments, state departments of education, and other state official and nonofficial groups dealing with some phase of child health work.

It is an official obligation for the regional chairman to arrange a meeting of the state chairmen of his region at all regional and national Academy meetings for the purpose of interchange of constructive ideas concerning the various state Academy programs. In addition, in all states where feasible it is desirable for Academy members to meet one or more times a year to discuss and arrange programs for meeting local child health needs. State chairmen should be fully informed as to the personnel of state subcommittees who are carrying on the work of the Academy's National Committees, should keep posted on progress, and should be available for assistance whenever it is desired. Both regional and state chairmen can do much in promoting the objectives of the Academy by stimulating Fellows to attend all regional and national meetings of the Academy.

These are but a few of the high spots bearing upon the topic assigned me for discussion. The American Academy of Pediatrics is one of the most potent organizations in existence today for the promotion of better health standards among children. To achieve its objectives requires the full cooperation of all its members. An important task of both regional and state chairmen is, together, to promote this cooperation.

CHAIRMAN HILL.—Many of you asked to have brought up for discussion the problem of conducting Academy affairs in states varying widely in population, size, and membership. Dr. Sterling Ashmun has had a number of years' experience as State Chairman of Ohio. Dr. Ashmun, how does the state chairman function in a large state?

DR. ASHMUN.—I find it difficult to carry out committee activities where the membership is so widely scattered. The members are no less interested in the various activities of the Academy but they just cannot get together for meetings.

I have been very pleased with the active interest that the members have taken in the State Medical Society section in Pediatrics, both in our state conventions and in the Postgraduate Education Program, in which we have been allotted a very fair share of the Five-Year Program.

I have failed very definitely in not distributing the many positions of honor that seem to fall to the state chairman himself, such as membership on Advisory Boards for Crippled Children's Care, Social Hygiene Society, Maternal and Child Health, Aid to Dependent Children, the Parent-Teachers' Organization, and the Committee on Education of the State Medical Society.

I am fully convinced that each member of the Academy should take an active interest in all phases of child health and child welfare in his community and every county society should have our members on appropriate committees where we can best serve children's needs. Every member should stand ready to further the education of parents in child care and disease prevention.

Frequent meetings, twice a year or oftener, of the members at some central point stimulate interest and serve to acquaint the members with each other and each other's problems.

Proper attention to the securing of new members of the Academy is a duty of the state chairman that is very difficult in a large state, but this is very important since all eligible qualified pediatricians should be members not only for the benefits he would enjoy for himself, but even more than that, every man can serve the general interest of all better when he works and cooperates with the group. I would not forget to mention the pleasure that has been mine because of the fine association with other state chairmen.

CHAIRMAN HILL.—Dr. Kennedy, would you tell us how the Academy functions in Minnesota?

DR. ROGER L. J. KENNEDY.—Dr. Kennedy of Minnesota reported that the Academy in that state has never conducted itself alone as an Academy organization but that its affairs have been directed chiefly through the Northwestern Pediatric Society and through the State Child Health Program of the State Medical Association or the Department of Health. About 50 per cent of the committee members on the various committees which have to do with child health in the state are Academy members.

CHAIRMAN HILL.—The State Chairman of Massachusetts, Dr. Warren Sisson has developed a unique and satisfactory system applicable to all the New England states. Would you tell us about it, Dr. Sisson?

DR. WARREN R. SISSON.—Dr. Sisson of Massachusetts reported that the Academy in New England works through other organizations in somewhat the same way as it does in Minnesota. In New England the work is particularly coordinated with that of the New England Pediatric Society. Dr. Sisson stated that there is a Council of the New England Pediatric Society which meets every second month. This includes members of the health department as well. Here problems concerning a particular area are discussed and acted upon as needed.

CHAIRMAN HILL.—From what has been brought out by the different speakers, I think we may conclude that child health needs vary widely in different states and that there is no set method of instituting Academy programs and objectives. Whether work is carried on under Academy identification or that of other organizations makes little difference. The important thing is the securing of results.

The next topic on the agenda for discussion is "The Relation of State Chairmen to the Work of the Academy's National Committees." It is my feeling that there is considerable need for a better understanding and a more active participation on the part of state chairmen in general in the important work these committees are doing. No matter how excellently the national committee maps out its program, the degree of success obtained is directly dependent upon the activity of the state subcommittee. Time did not permit the appearance at this meeting of all the Academy's national committee chairmen to explain their programs to you. However, several chairmen of the more active committees are here. First, let us hear from Dr. Fairfax Hall, Chairman of the Committee on Contact Infections.

DR. HALL.—The efforts of the Contact Infection Committee have been directed mainly toward preventing tuberculosis. We have urged finding all persons who may become a source of infection to children, and, as even more important, discovering the source of infection in every child who develops a positive tuberculin reaction, in order to break any existing contact.

We have jointed with the American School Health Association in attempting to arrange for all schoolteachers a physical examination which would include tuberculin tests and lung x-rays. This has become an established custom in many cities, among them New York and Kansas City. In others, such as St. Louis, it has been impossible to make much headway in this direction.

Tuberculosis examination of nurses and interns is a routine procedure in most hospitals. It is equally important that nurses' aides and other workers brought into hospitals by the present emergency should be included in this preventive health measure for their own benefit as well as for the protection of children.

Another group to which we can well turn our attention is comprised of prospective mothers. During pregnancy, lung x-ray, as a means of finding and preventing the spread of tuberculosis, is of importance scarcely secondary to the Wassermann test which is made at this time. We could well use our influence with obstetricians

to make it an established practice to have a chest film taken during pregnancy. It is hoped that the Children's Bureau will take this up as a worth-while health measure.

Pre-employment health examination of nursemaids and domestic workers is highly desirable. The present scarcity of help in homes makes this very difficult to insist upon and more difficult to obtain. It should be done, however, whenever it can be arranged.

Examination for tuberculosis of the family as a *unit* has been emphasized by Dr. Chester Stewart. The American Trudeau Society has endorsed this plan and offered to cooperate with the Academy in its accomplishment. In order to establish common ground on which to work this out, the following points have been offered by this Committee:

1. Every child should be tuberculin tested at frequent intervals, best annually, as long as he remains negative.
2. Adult family members and domestic workers should have chest x-rays unless their tuberculin tests have been found negative. Tuberculin tests of these persons may be done by the pediatrician at the same time that the children are being tested or by another physician.
3. Whenever a child is found to have a positive tuberculin reaction, it is *urgent* that all adults closely associated with this child should have a thorough examination in an effort to find the source of infection.
4. Examinations of adults for tuberculosis should not be made by the pediatrician, but, whenever possible, by qualified specialists in this disease, or by the family physician.
5. Open cases of tuberculosis should be segregated and removed from children until there is no longer danger of dissemination of tubercle bacilli. The American Trudeau Society favors it as a means of increasing knowledge in regard to tuberculosis in those families where it is carried out.

While this program is idealistic and difficult to put into practice at the present time, we feel that the principle is correct and should be adopted as an official program of the American Academy of Pediatrics and American Trudeau Society.

Tuberculosis is expected to increase during the war due to overwork, crowding, poor housing, and inadequate food. There are many ways in which this Committee can use its influence to combat these conditions. This may be done through local health authorities with aid when possible from the U. S. Public Health Service and other Federal Agencies.

Nurseries for war workers' children are being opened all over the country. It is important that the adult personnel be checked up carefully so as to prevent contact infection. In New York City there are 338 nurseries and nursery schools. The Health Department of this city has offered free chest examination for all of their employees. When nurseries are connected with industrial plants having x-ray facilities, this equipment should be put to use examining those in charge of the children.

X-ray examination of the men of our Armed Forces will disclose and make possible the control of many potential sources of infection for children. Since it is expected to include all who are in military service, it will mean eventually x-ray of as many as ten million men. This will focus public attention on the value and need for universal chest films. The Army and Navy are at present using all obtainable miniature chest film equipment for this purpose. When there is no longer such need, these machines will again be available for the civilian population. We hope this will be the case in the near future, because of the low cost of this type of lung x-ray.

Since enlistments have broken up the Contact Infection subcommittees in the states to such a large extent, it is necessary that each member of the Academy individually carry out the principles of tuberculosis prevention in his private practice as well as in his public health work. Encouragement by you, as state chairmen, of the recommendations of the Contact Infection Committee will greatly facilitate this.

CHAIRMAN HILL.—Next let us hear from Dr. Albert Kaiser, Chairman of the Committee on Cooperation with Non-Medical Groups and Societies.

DR. KAISER.—During the last year, as Chairman of the Academy Committee on Cooperation with Non-Medical Groups and Societies, I endeavored to communicate with all of the state committee chairmen. Though I sent three personal communications to each committee chairman during the year, I received reports from only about one-third of the states. These reports indicated genuine interest on the part of the committee chairmen, which resulted in effective cooperation with nonmedical groups in those states. Indirectly I learned that the activities of this committee were being advanced in several unreported states but the designated channels were not responsible for this accomplishment. It seemed evident to me, therefore, that successful committee activities resulted where committee chairmen worked in conjunction with state chairmen. Where state chairmen were not aware of national committee activities, little was being done. As has been stated by previous speakers, it appears essential that the state chairman must be the key Academy representative in each state and through him must be cleared all committee activities if the Academy activities are properly carried on in each state.

The state chairman, if familiar with the purpose and objectives of national committees, can intelligently select a committee chairman in his state. A poor selection for a chairman of a state committee usually results in ineffective work for that committee.

I believe a state chairman should acquaint himself with all child health activities in his state. It will be found that many activities are carried on by physicians who are not Academy members. However, if the state chairman contacts those already engaged in these activities and informs such individuals or groups of the Academy's interest in their problems, the state chairman will eventually be regarded as an advisor to these activities and will be called upon to assist in the prosecution of varied child health activities.

I am happy that this meeting has been possible in order to clarify the relationship between the state chairmen and the committee chairmen representing national committee activities.

CHAIRMAN HILL.—Dr. Edward Clay Mitchell, President of the Academy and Liaison Officer between the Academy and the American Legion, will talk to us about the Academy's Cooperative Program with the American Legion.

DR. MITCHELL.—The subject assigned to me is "How Can the Academy Best Cooperate With the American Legion Child Welfare Division?"

It is our contention that by starting at the very foot of our social structure, the next generation, and strengthening the mental and moral fibers of that group, we shall build a firm foundation without which the rest of our program might well crumble.

The slogan of the Academy is "To foster and stimulate interest in pediatrics and correlate all aspects of the work for the welfare of children which properly come within the scope of pediatrics."

The Legion wishes to assist in every way possible worthy established societies and groups in raising the child to be physically, mentally, and morally strong; to be a good American. The German child is raised to be "cannon fodder." The

Japanese child is taught to believe that sacrifice for his country insures full reward in future life. The American child is raised to live and to protect his country.

The Legion believes that all education should begin in the home. Any plan in which the father and mother can participate can be more successful than one outlined for them, even though they can be given financial and other assistance. The American Legion has 1,130,000 members. This represents virtually that many American homes. In addition to this there are a number of veterans of World War I that will join when they know the Legion is doing worth-while work. This Legion will be increased seven or eight million when the veterans of World War II become members.

The Legion is divided into areas, the areas into states, and the states into individual posts. I mention this to show that the Legion is represented in every town and can be represented in every home in America. This would be an ideal organization to begin and continue an educational plan in the home.

The Academy is particularly interested in the physical development of the child and is willing at the present time to sponsor only this phase. The Academy has developed the Child Health Record, Report of Committee on Immunization and Therapeutics, and Health Appraisal of the School-Aged Child. It has at present a film on "When Bobby Goes to School" and is developing a film on "Nutrition."

Last year the Council recommended, and the Academy agreed, that each state chairman appoint a member to act in liaison in that state with a member appointed by the American Legion. This was done by all the states. A table of the various appointees was given in the year's roster. Unfortunately, with but few exceptions, the appointees did not work.

I wish this morning to hear from two of the state chairmen. First is from my own state of Tennessee. I call on this chairman because the state has done nothing, but Dr. Jacobs has a plan that he wishes to present. Dr. Jacobs.

DR. ARTHUR G. JACOBS.—As Co-Chairman for Tennessee, I wish to urge our cooperation with the American Legion, particularly in that branch of their activities concerned with our own work, the welfare of the child.

It is particularly fitting that Tennessee should emphasize this activity, because our president, Dr. Edward Clay Mitchell, also enjoys the position as member of the Executive Committee of the National Child Welfare Group of the Legion.

Tennessee also occupies the unique position of having the further honor that the National Commander of the American Legion, Colonel Roane Waring, is a Memphis man. Colonel Waring is greatly interested in the well-being of the child and can be counted on to give us all possible support and assistance in all that tends to the welfare and health of a child.

The Legion now has 1,130,000 members and will soon have over 7,000,000. It is one of the most powerful organizations in this country, and it has evinced a willingness to proceed to great lengths in cooperation with us in all those measures that make for a healthy, vigorous child.

The American Legion has a Child Welfare Group. Dr. Mitchell will stress this proposition in his address and wishes to interest you also in this activity. I understand that no great interest has so far been manifested in this problem by the Academy. However, there is one notable exception and I wish to call your attention in this respect to Dr. Wylder, of Albuquerque, N. M., who has accomplished brilliant results with the able assistance of Dr. Adler, and I am sure he will be pleased to tell you of his accomplishments.

Of course, each state has its own problem to be solved in its own way, and there is no one procedure that will be applicable to all of us. The Legion believes that training should begin in the home and the mother should be convinced of this and converted to this way of thinking and we will succeed in obtaining good health

and proper mental training of the child. The possibilities here and the opportunities offered us by the American Legion are very great and it would pay to take advantage of them right now.

You may raise the question, What can the American Legion do to help in this matter? In answer I will say that the American Legion has the power, it has the influence, it has the earnest wish to see this work through and it has the money or can get the money.

This is the psychologic moment to pursue this matter, because Colonel Waring may not always be National Commander and Dr. Mitchell may not always be on the Executive Committee.

DR. MITCHELL.—The next man I shall call on because he has done splendid work. He and Dr. Adler have really taken their job seriously. Dr. Wylder will present the New Mexico program.

DR. M. K. WYLDER.—The influence of the American Academy of Pediatrics in New Mexico during the past year has been both direct and indirect. There has been the expected impact of the war effort upon all endeavors by physicians and, at the same time, a realization of the greater need for guidance in everything affecting child welfare.

Members of the Academy are serving as chairmman of the State Board of Health, as Director of Maternal and Child Health in that department, and on examining boards for selective service.

The Academy interests are being served and their standards advanced in various parts of the state through participation of Academy members in direct service in clinics and conferences. Our members have spoken on many occasions before American Legion Locals, American Legion Auxiliaries, and the state meeting of the American Legion; luncheons, clubs, and State Nurses' Associations; radio broadcasts, both in English and in Spanish; parent-teacher meetings, institutes, other professional and lay groups, and the State Medical Society.

One member has published several articles on child welfare.

The health committee of the State Parent-Teachers' Congress is headed by one of our members.

Cooperation has been arranged to further the joint program of the American Legion and the American Academy of Pediatrics, and it is regrettable that more has not been accomplished through this very excellent tie-up.

The picture, "When Bobby Goes to School," has been shown to more than one-half of the physicians in the state during the past year. It was approved by every county medical society where shown, and there are only three county medical societies that have not yet had the opportunity to see the picture.

Numerous lay organizations have had showings of the picture after approval of county societies had been obtained.

The picture, "Immunization Procedures," has been shown several times, and six showings in the state before as many county societies are scheduled for December, 1942.

Incidentally, the members have done a great deal to advance the immunization program throughout the state. The procedure in most of the county health units is, in part at least, guided by the efforts of Academy members.

Literature issued by the Academy has been made available to those concerned, and plans are now being made to purchase and distribute a considerable quantity of the new edition of the brochure on the immunization procedures.

A number of physicians in the state interested in pediatrics have received the friendly encouragement of members of the Academy.

Those few physicians who are Academy members in New Mexico will wholeheartedly endeavor to further the aims of the Academy in every way possible at a time when a topsy-turvy world finds increased demands upon the guardians of child health and welfare.

DR. MITCHELL.—I wish to quote Field Marshal Jan Smuts who described this conflict as a second thirty-year war interrupted by an Armistice in 1918.

There will be many problems, both during this period of conflict, and in the reconstruction period afterward, which will affect the child.

Because of war work, there will be a changing population. Many families will be moved into new and congested communities. They will need pediatric guidance. There will be much legislation during this war period and the reconstruction following. This again should be carefully supervised. The Academy has the pediatric knowledge which should be disseminated into the American home. The Legion composes a cross-section of the American public. It is represented in every city, state, and village of the United States. In most of these communities it has an active auxiliary.

Many members of the Academy who are prohibited from going into active service because of age and physical disability are anxious to work. This liaison with the Legion offers every man an opportunity to become active. By its publications, by supervision of scenarios, both movie and sound slides, and by the active participation of its members in lecture programs, the Academy can do a large amount of good by initiating with the Legion an educational program which will require no large grant of money.

In closing, every state can accomplish what has been accomplished by Doctors Wylder and Adler in New Mexico if the state chairmen really become interested and appoint a man who will work.

CHAIRMAN HILL.—Thank you, gentlemen, for your most informative remarks. Is there any discussion from the floor?

DR. PARK J. WHITE, Co-Chairman of Eastern Missouri.—Dr. White reported on his efforts to get schoolteachers of St. Louis examined for tuberculosis in spite of opposition on the part of the teachers. He also mentioned the work of Co-Chairman Dwyer who, as health commissioner of Kansas City, has been able more quickly to put through such a program.

He stated that x-raying the chests of pregnant women is of great importance in the prevention of infection of the newborn but that tuberculin testing of such women might not be without danger.

He concluded by saying that many of the national committee programs might be opposed by some groups as "state medicine" but that as an organization primarily interested in child welfare, the Academy would not be so likely to entertain such fears.

CHAIRMAN HILL.—The most frequent topic, by far, which you state chairmen indicated in your letters you would like to have discussed had to do with the pediatrician's problems in civilian practice during wartime. In the agenda your requests have been grouped under three broad headings.

1. Problems related to industrial, defense, and agricultural areas.

2. Cooperation by pediatricians in government-sponsored programs such as the Maternal and Child Health and the Crippled Children's Program, especially as it relates to inclusion and exclusion of cardiac children.

3. Consideration of need for a revision of methods of practice, with especial reference to group service at reduced rates as a contribution to the war effort in local communities.

It required no searching about to find the one person in America best qualified to discuss these and related problems with you. Dr. Martha Eliot, Associate Chief of the Children's Bureau in Washington and a Fellow of the Academy herself, needs no introduction to any Academy audience. As you know, she has observed the children of Great Britain under war conditions, and she has traveled far and wide in this country gaining information first hand about the problems confronting our own children.

DR. MARTHA ELIOT.—Dr. Martha Eliot first asked for all the help and suggestions she could possibly have from the Academy as the problem is a great one. In many defense and industrial areas there is no plan for the care of mothers and children, and it is of utmost importance that a definite health program be developed in these areas. Federal agencies are at work on the problem at the present time, and it is desirable that they cooperate with state and local health departments. The Academy can be of great help in effecting this cooperation. There is the great problem of crowded maternity hospitals and nurseries for newborn infants. Under these conditions, of course, infections are a great danger.

There is the problem of obstetric care for the wives of men in the military service and their offspring. Funds have been set aside in Washington for the medical and hospital care of these mothers and for their infants during the first year. It is estimated that about one in four of the men in the Army are married. For this work, of course, increased funds are necessary.

Another great problem is the health and well-being of children of secondary school age in defense and industrial areas. It is most desirable that health examinations and conditioning programs on a nation-wide basis be established. There is the problem of health supervision in the various work camps to be established in the country.

It is desirable that there should be a committee on child health under each local defense council, this committee to work through the Committee on Children of the State Defense Council. The Academy certainly should be represented on all such committees having to do with child health programs. The state chairmen are particularly urged to communicate with the State Defense Council relative to the use of pediatricians on these committees.

Dr. Eliot reported that there are two bills now before Congress which will enable the establishment of the needed funds to carry on child health work throughout the country. These bills do not directly appropriate money, but they authorize the appropriation of increased funds under the Social Security Act, Title V. (The bills referred to were H.R. 7303 and S. 2738 which were before the 77th Congress but were not acted on.)

Dr. Eliot used the last moments of her allotted time to answer questions from the floor.

QUESTION.—How many states have maternal and child health directors?

ANSWER.—All states.

QUESTION.—Is there a plan to provide ways and means for pediatricians to go into defense areas where needed?

ANSWER.—No comprehensive plan exists. The Procurement and Assignment Service has provided for some transfers of physicians but not many. The need for it is great.

QUESTION.—What about the care of unmarried mothers and illegitimate children under the program of maternity and infant care for service men's wives?

ANSWER.—They are receiving the same care and consideration as the others.

QUESTION.—Are funds available to organize pediatric teams to go to communities which need them?

ANSWER.—There certainly should be such funds available, but they are not.

QUESTION.—Should a clinic be provided for medical care even though people have the money to pay a private physician?

ANSWER.—Many people have to be educated to seek medical and hospital care whether or not they have money to pay for it. Where clinics are needed appropriate plans should be made so that people may pay the clinic as is done in many cities today. In some areas it is quite possible that some group method of practice will have to be developed to meet the need caused by the wartime shortage of doctors. This might well give many communities an opportunity to try out new methods of providing care.

CHAIRMAN HILL.—I am sure I speak for everyone here, Dr. Eliot, when I say to you that we greatly appreciate your meeting with us this morning. It is regrettable that we do not have more time to continue this phase of our discussion. Before we adjourn, does anyone have anything further to bring up?

An unidentified speaker brought up the subject of the need for allocation of doctors in the various states. The problem of how physicians moving to other states might be licensed was discussed, but no conclusion was reached.

DR. OLIVER L. STRINGFIELD.—Dr. Stringfield, of Connecticut, reported on how they are attempting to solve the problem in his state. They have worked through the state medical director and to date have managed to furnish physicians in needed areas. The state has published a handbook on child care which has been of great value in the care of children in the state.

DR. NICHOLS.—Dr. Nichols finally urged that each chairman return to his home state and immediately set to work to secure strong coordination and cooperation between the various agencies of the state which are concerned with child health, particularly the child and maternal health bureaus, the state health and welfare aids, and the defense councils.

News and Notes

The following dates have been set for examinations to be given to candidates by the American Board of Pediatrics:

Written examination, locally under a monitor, Feb. 4, 1944.

Oral examination, Philadelphia, Pa., March 25 and 26, 1944; San Francisco, Calif., May 6 and 7, 1944.

Application for space in the scientific exhibit to be held at the Convention of the American Medical Association in Chicago, June 12-16, 1944, should be made either to Dr. Sterling Ashmun, representative, for the Pediatric Section, 117 So. Main St., Dayton, Ohio, or directly to the Committee on Scientific Exhibits of the American Medical Association, Chicago.

Word has been received of the death of Dr. George B. Kryder, of Glendale, Calif., on November 19, shortly after his release from the Army.

Dr. Henry E. Irish, of Chicago, died on December 11.

Book Reviews

Allergy, Anaphylaxis, and Immunotherapy, Basic Principles and Practice. Bret Ratner, M.D., Baltimore, 1943, The Williams and Wilkins Co., 809 pages, illustrated. Price, $8.50.

The incidence of allergy is increasing. To a great extent it has become a disease of civilization. The various manifestations of allergy are encountered in all branches of medicine—to know medicine, therefore, one must know allergy. The induction or acquisition of hypersensitivity is becoming more apparent as a complication in the administration of many therapeutic procedures. Progress in our knowledge of allergy is dependent to a great extent upon an understanding of the fundamental mechanisms involved in its development. The author presents these fundamentals in a very comprehensive manner. A great deal of attention is directed to serum allergy because, as the author points out, "to know serum allergy in all its essentials and its many wide ramifications would in essence give one the genesis and fundamentals of allergy in general."

In Book I the principles and practice of immunotherapy are discussed in relation to the materials used in diagnosis, prophylaxis, and therapy of infectious diseases. The author shows how allergy may result from the misuse of therapeutic agents. A detailed discussion is also presented on the actual treatment and prophylaxis of infectious diseases. Particular emphasis is placed upon the prevention of allergic catastrophies. The conservative administration of various sera and the sulfonamides is therefore advised.

Book II is devoted to allergy to immunotherapeutic agents. In an introduction to the study of the allergic state the evolution of our present knowledge of hypersensitiveness is reviewed. In a series of excellent photographs the exposition of the allergic state is clearly illustrated. Serum sickness is then presented from the standpoint of its clinical manifestations, laboratory findings, diagnosis, and treatment. The acquisition of serum allergy is discussed from the viewpoint of accelerated serum reactions and the modes of acquisition of serum allergy. Then serum allergy is described as to diagnosis, clinical manifestations, symptomatic therapy, and prevention. Finally, serum sickness and serum allergy of the central nervous system are discussed as to clinical manifestations and management. Additional sections of the book are devoted to reactions and accidents due to blood transfusions and to drug allergy.

In Book III the allergic state is presented from the standpoint of physiological pathology, the blood changes in allergy and anaphylaxis, and the underlying mechanism of the allergic state.

The text is well written and illustrated. It is replete with references to all the important contributions in the literature on the subjects as presented. Only an author can truly appreciate the amount of time, intense effort, and enthusiasm necessary to compose a text of this type.

F. K. H.

Better Homes and Gardens Baby Book. Gladys D. Shultz, 1943, Des Moines, Iowa. Meredith Publishing Co., 258 pages. Price, $2.50.

A handbook for mothers by the Director of the Child Care and Training Department of the *Better Homes and Gardens* magazine. The author has had some ten years' experience in conducting this department and hence is well qualified to know the questions commonly asked and the type of information sought by mothers. Dr. P. C. Jeans has reviewed and criticized the material dealing with the infant from birth to 2 years of age, and Dr. Lee Forrest Hill has supervised the entire volume, so the accuracy of the material in the book can be relied upon. The book has been written from the viewpoint of our present wartime conditions of living so far as advice as to foods, clothing, and the like is concerned. A short section on prenatal care and the necessary preparation for the baby is followed by a section on the baby from birth to 2 years of age. This is subdivided into the usual periods in which development, feeding habits, etc., for the specific age are discussed. The third section concerns itself with the 2- to 6-year age period. Additional chapters on food recipes, books, and music complete the book except for a large section devoted to Records. This last to the reviewer is far too extensive and would be much better with radical eliminations. As a whole it is an excellent book with sound advice, attractively presented and in keeping with present-day thinking. The book is well illustrated and with illustrations of real pedagogical value. The text, written by a professional writer with years of experience in dealing with young mothers, carries the message much better than the average "baby book" by a doctor inexperienced in writing for the laity.

Epitome of the Pharmacopeia of the United States and the National Formulary With Comments. Ed. 7, Chicago, 1943, The American Medical Association Press, 271 pages. Price, $1.

This small convenient book is a companion piece to *Useful Drugs*. Because the Pharmacopeia and the National Formulary contains much technical information which is of little value to the physician, this epitome has been prepared. It is designed to include the information contained in the two books which is most

useful to the physician, with statement of the action and uses of the drugs described. Those items which are considered to be without therapeutic value are commented on adversely. The book has been prepared under the direction of the Council on Pharmacy and Chemistry of the American Medical Association.

McCULLOCH

New and Nonofficial Remedies, 1943. Editor, Austin E. Smith, Chicago, 1943, The American Medical Association Press, 772 pages. Price, $1.50.

Lists and describes the articles which stand accepted by the Council on Pharmacy and Chemistry of the American Medical Association on January 1 of the year of publication. The present volume has been revised in accordance with specifications of the U. S. Pharmacopeia XII and the National Formulary VII. Describes all the changes which have been made during 1942. Issued under the direction and supervision of the Council and includes the official rules of the Council. During the succeeding year, descriptions of other medicinal substances as are accepted by the Council are printed in the form of supplements, which are sent to those who purchase this book.

McCULLOCH

Accepted Dental Remedies. Ed. 9, Chicago, 1943, The American Dental Association, 304 pages. Price, $1.

Lists and describes those pharmaceutical articles which stand acceptable to the Council on Dental Therapeutics. The list includes those official drugs and preparations which are considered to be of greatest usefulness in this field of industry and nonofficial articles marketed in conformity with the rules of the Council. This ninth edition represents a more comprehensive revision than many of the preceding ones. The Council has voted to delete all brands of arsenicals, betanaphthol, bismuth, cresatin, silver lactate, colloidal silver, and sodium peroxide.

The book is arranged similarly to *Useful Drugs* and *Epitome of the Pharmacopeia.* It is a reliable compilation of useful drugs in the dental profession and includes the recognized dentifrices with references to those which have been rejected. Revised annually.

McCULLOCH

Gregg Medical Shorthand Manual. Effie B. Smither, ed. 2, Chicago, 1942, The Gregg Publishing Co., 191 pages. Price, $2.

While this book is nonmedical, it is an essential part of the training, ability, and skill in a doctor's work. Records of every sort are essential and since many or most of their making is done by secretaries, the proper training of that person is essential. So this small book will be a valuable aid. The second edition shows but a few changes from the first which was issued sixteen years ago.

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